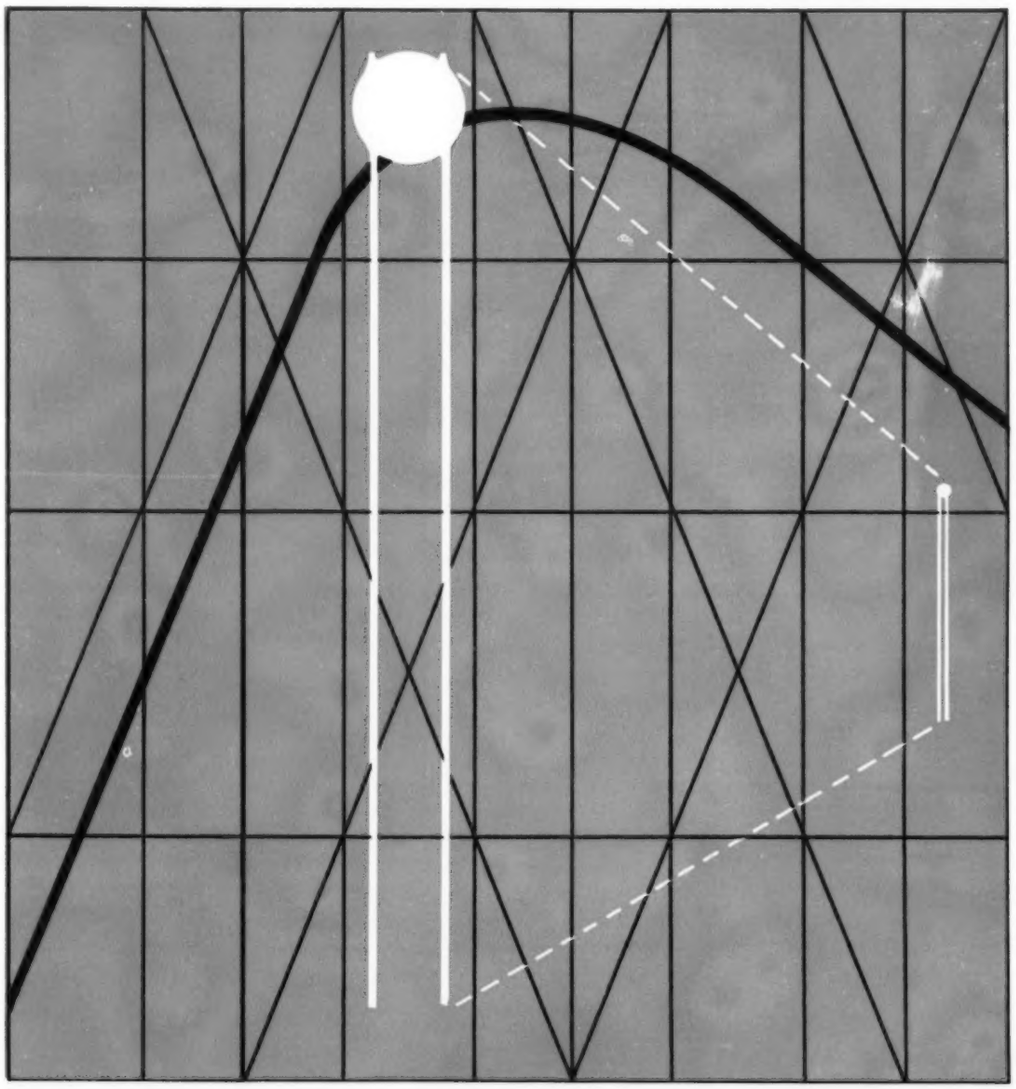
MILITARY SYSTEMS DESIGN

JULY-AUGUST 1961



featuring:

What is "Epitaxial?"

Solid-State Control of Microwaves

New Order of Resistor Reliability

Muffin Fan

Precision Tachometer Generator

Electronic Circuitry

High Temperature Control
Biological Stimulus Isolator
Medium Hi-Speed Line Driver
Thermistor Thermometer-Alarm
Reverse Recovery Time Test
Amplifier has Hi-Input Lo-Output Impedance
Sensitive Monostable Multivibrator

cover article:

The Thermistor—A Specialized Semiconductor Sensor

ROUTE THIS COPY TO

INSTRUMENTS PUBLISHING COMPANY • PITTSBURGH 12, PENNSYLVANIA

MSD MILITARY SYSTEMS DESIGN

Published bimonthly by Instruments Publishing Company Inc., 845 Ridge Ave., Pittsburgh 12, Pa. Printed at 1600 N. Main St., Pontiac, Ill. Accepted as Controlled Circulation Publication at Pontiac, Illinois.

BPA

Richard Rimbach, Publisher

Claude O. Morrison, Editor
(Commander U.S. Naval Reserve)

Fred D. Marton ..... Associate Editor
Josephine Martin ..... Associate Editor
John Moriarty ..... Eastern Editor
Robert B. Forest ..... Western Editor
Raymond C. E. Smith ..... Art Director
Robert E. Becko ..... Production Manager

Main Office: 845 Ridge Ave, Pgh 12, Pa., Fairfax 1-0161

Richard Rimbach, Jr., Sales Manager
New York, Murray Hill 8-0980

Advertising Representatives

Boston 16—Harold H. Short, Jr., 269 Maine St., Stoneham, Mass., 438-3982

Chicago 6—Harold W. Haskett, Madison Terminal Bldg., 9 S. Clinton St. Central 6-8963.

Clearwater, Florida—Evert F. Nordstrom, 1651 Sherwood St., Clearwater 441-9033

Cleveland (Shaker Heights) 22—Max G. Bauer, 3310 Warrensville Center Rd. Wyoming 1-7145

Los Angeles 34—John J. Fahey, 2639 S. La Cienega Blvd., Upton 0-8442

New York 17—Richard Rimbach, Jr., Room 359, 525 Lexington Ave. Murray Hill 8-0980

Pittsburgh 12, Penna.—R. Brandegee 845 Ridge Ave., Fairfax 10161

Philadelphia 4—Robert V. Frey, Suite 100, 101 N. 33rd St., Evergreen 2-3878

San Francisco 11—Charles Clark, 420 Market St., Douglas 2-3899

St. Louis 1—Steve Wright, Room 416, 4 N. 8th St., Chestnut 1-1965

Subscriptions

Circulated without charge to qualified engineers and executives in organizations which develop, manufacture, purchase, install, or maintain electronic and control equipment and systems for military applications; officers and engineers in the Armed Forces responsible for design specification, test, or maintenance of such equipment; scientists and engineers in development and research for the Armed Forces. Qualified individuals in the United States may request this publication by providing the following information on their company letterhead: Your name and title; your job function as related to your company's products or services for the military; your company's name, address, and nature of business as related to military end products or applications. Available to others, by subscriptions, at the rate of $10 per year.

MSD MILITARY SYSTEMS DESIGN

PRINT ORDER THIS ISSUE: 45,700

VOL. 5, NUMBER 4
July-August 1961

ELECTRONIC CIRCUITRY

ARTICLES DISCUSSING RESISTIVE COMPONENTS

ARTICLES EMPHASIZING MICROWAVE TECHNIQUES

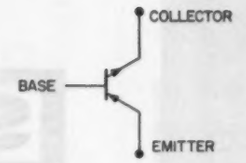
OTHER ARTICLES IN THE FIELD OF SYSTEM COMPONENTS

COVER: Posed on a background suggesting a Thermistor Current-Voltage characteristic, enlarged and actual-size projections of a semiconductor Thermistor (see p. 14) represent our emphasis on Resistive Components. New Microwave Devices are also emphasized and New Products featured at WESCON '61 are previewed in a large separate section.

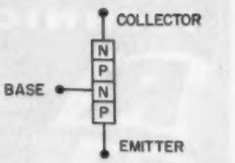
WESCON PRODUCT PREVIEWS 36-62

REGULAR FEATURES

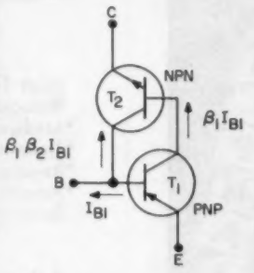
**Indicates article which discusses theory, application, test or development of Semiconductor Devices.*



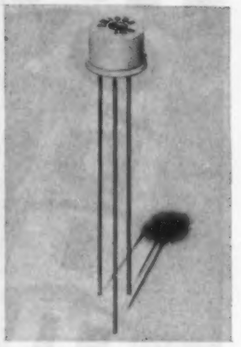
DYNAQUAD CIRCUIT SYMBOL



PHYSICAL REPRESENTATION



TWO TRANSISTOR ANALOGY



PNPN Device

RELIABILITY of any circuit design can, in general, be increased by: (1) Simplifying the circuit, and (2) using components which inherently are more reliable.

Semiconductor technology has given the designer a variety of components which make possible new orders of circuit simplicity. Unfortunately, the more sophisticated the component, the more difficult it is to make, and over all reliability gained through circuit simplification is lost because the components have become less reliable.

For the designer who can simplify his circuit with a solid state switch, this dilemma has been removed by the new Tung-Sol Dynaquad device—a base controlled four-layer switching device made by exactly the same number of manufacturing steps and controls as a conventional transistor—and therefore having the same reliability and price range as a conventional transister.

The Dynaquad is a germanium, three-terminal, PNPN structure packaged in a standard TO-5 case (Fig. 1). Basically a two-position switch with capacities and speeds normally associated with digital computers, it switches in the megacycle range, with rise times in the order of 0.1 μsec and is capable of providing an output voltage swing of 35 volts.

In its normal operation, the Dynaquad is turned on by applying a small negative pulse to the base, and it remains on after the signal is removed. Turn-off is

FIG. 1. DYNAQUAD base-controlled four layer switching device.

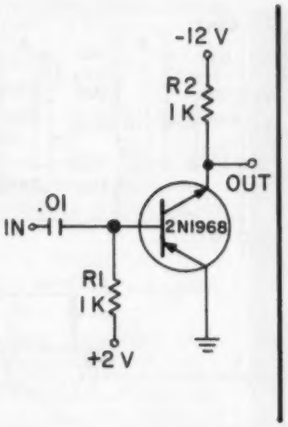
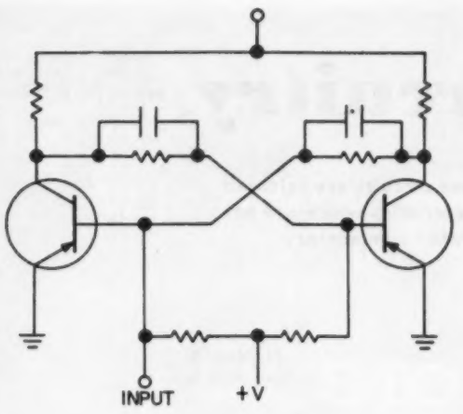


FIG. 2. DYNAQUAD Flip-Flop circuit compared with conventional transistor flipflop on right.



DYNAQUAD FLIP-FLOP CONVENTIONAL FLIP-FLOP

Simplifies Digital Circuitry

accomplished by applying a positive pulse to the base, or by momentarily dropping the collector current below the sustaining point.

Theory of Operation

The Dynaquad is the circuit equivalent of two complementary transistors—an NPN and a PNP—as shown in Fig. 1. The first stable state of the Dynaquad is the OFF condition where the current flow is limited to leakage currents. If now a small base current (I_{B1}) is applied at B in the direction required to turn T1 ON, then its collector will have a current B_1 I_{B1} due to the gain B_1 of transistor T1. This current B_1 I_{B1} becomes the drive current for transistor T2, which produces a collector current in T2 of B_2 B_1 I_{B1}. This now becomes the injected current into the base of transistor T1.

When the product B_1 B_2 becomes greater than unity, the system becomes self-regenerative and the collector current of T2 increases to a value limited only by the circuit impedances. The Dynaquad is now in its second stable state, that of saturation.

In order to return the device to its OFF state the regenerated current can be interrupted by either reducing the collector supply current below the sustaining value or by momentarily injecting a reverse current (positive) into the base B, sufficient to stop the regenerated current.

As stated earlier, the Dynaquad manufacturing technique is unique in the design of multilayer devices. Conventionally, the four layers are formed by multiple diffusion and a critically controlled etch. Although this process may be varied, in all cases the junction formation or the final fabrication requires systems and controls that are considerably more complex than those required for the alloyed junction transistor. The result is a more costly component that is also more susceptible to defects.

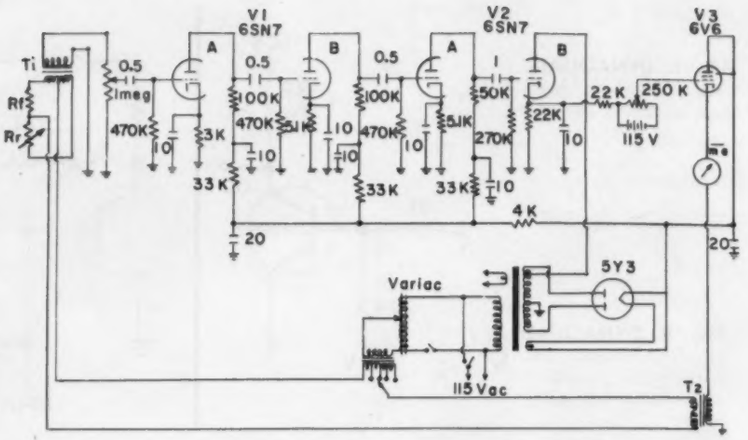
With the Dynaquad, Tung-Sol Electric Inc., Newark, N. J. has developed a technique for forming multiple junctions with the same simplicity and reproducibility as single alloy junctions.

Simplified Flip-Flop Circuit

The simplified flip-flop (Fig. 2-a) using a Dynaquad is compared with the conventional transistor circuit (Fig. 2-b). Here a single Dynaquad replaces seven components in the conventional transistor flip-flop circuit. When a negative pulse of 0.3 ma max. is applied at IN the unit turns on, raising the output voltage from —12 v to 0 v. A positive pulse of 2.5 ma (min.) applied to the base turns the unit off changing the output from zero volts back to —12 v. A sustaining collector current of 5 ma (max) is sufficient to hold the Dynaquad in the ON state, while normal collector current at 25°C is 20 ma for the 2N1968. Other Dynaquad types are the 2N1966 (I_c = 50 ma) and the 2N1967 (I_c = 100 ma).

Electronic Circuitry

A continuing MILITARY SYSTEMS DESIGN feature, these circuits are selected because they represent good design. Significant characteristics which are not self-evident from the diagram are explained in the printed commentary.



FURNACE
Temperature
Control

HIGH TEMPERATURE CONTROL

Furnace-element temperature in a small mass spectroscopy evaporation chamber is controlled by use of the circuit shown. Using the principle that the resistance of the furnace heating element, R_f, at a particular temperature will be constant, its temperature is balanced against a large variable reference resistor (R_r) having a low temperature coefficient.

A signal proportional to the inbalance between the two resistances R_f and R_r, with R_f normally being the smaller, is received by the secondary of the detecting transformer T1, which is amplified in a conventional 3-stage resistance coupled amplifier using 6SN7 triodes. The fourth stage (V2-b) cathode follower, is unconventional in that its ac plate supply establishes a suitable phase relationship to the signal. This phase relationship permits the signal to pass this stage only when the resistance of R_f is less than that of R_r.

Only signals to the grid of V2-b during the positive half-cycle of plate potential are effective. If the incoming signal alternation is positive during that period, dc output voltage is higher than during null signal condition. If negative, the dc output will be lower than during null condition.

The output of the cathode follower stage (V2-b) is filtered dc applied to the grid of the 6V6 power tube through a biasing battery-potentiometer arrangement which permits accurate adjustment of the plate current null for zero-signal input. When the potential of the V2-b output exceeds that of the battery bias, the plate current of the 6V6 is increased. The plate current in turn controls the saturable reactor T2, with increased plate current decreasing the impedance of the heating power circuit. Although the automatic compensation of temperature deviation is good, manual control through the Variac—with the operator watching the null point of the plate meter—provides an additional control if needed.

Heater voltage: 0-24 v, 60 cps.

Heater current: 0-340 ma, rms 60 cps.

R_r resistance range: 19-70.6 ohms for temperature range.

Temperature range: 25°C

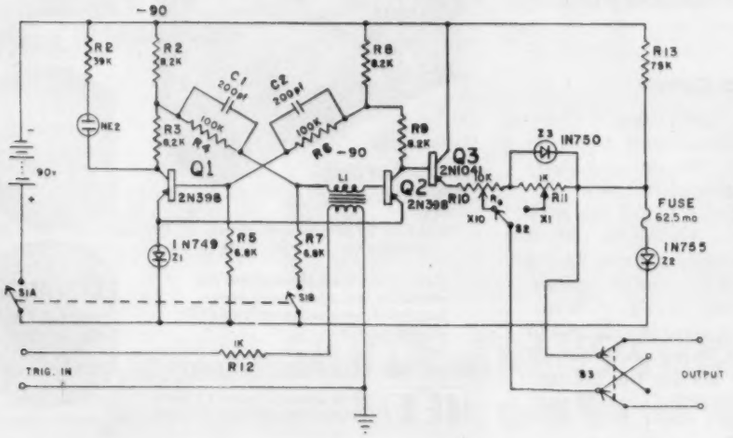
Line voltage: 115v 60 cps.

Source: Mr. Soon Bok Hong, Scientific Research Institute, Ministry of National Defense, School, Korea, also *Review of Scientific Instruments*, November 1960, article by Messrs. Shin, Hahm, Kwon, Jo and Hong.

BIOLOGICAL STIMULUS ISOLATOR

In biological experiments the use of electrical stimulating pulses isolated from ground is often essential. Because electrostatically screened transformers suffer from poor pulse duration and overshoot, a pulse generator which is itself isolated from ground is often used to provide the isolated stimulus. The circuit provides such an arrangement.

The circuit is composed of a bistable saturating multivibrator using 2N398 pnp germanium transistors powered from a 90 v rechargeable cadmium battery. The multivibrator is triggered by a pulse of approximately 5 v through a ferrite pot-core transformer (T-1), electrostatically screened to isolate primary and secondary windings. Switch contact S1A is arranged to make before S1B to ensure that Q2 will saturate when the instrument is turned on. The leading edge of the trigger pulse then turns the stimulus isolation unit (S.I.U.) on, and the trailing edge turns it off. Saturation current flowing through zener diode Z1 supplies the multivibrator bias.



STIMULUS
Generator is
isolated
from ground

At the instant the switch S1A contact closes Q1 is reverse biased, with its base 4.3 volts more positive than its emitter causing it to cut off, which applies a strong negative potential to the base of Q2, while its emitter is held at —4.3 v. This bias causes it to start conducting immediately. A moment later contact S1B closes, applying a more positive potential to the base of Q2 and establishing the voltage divider chain R2, R4 and R7. Q2 saturates at a safe current value due to the large voltage drop in R8 and R9 and to the high resistance of R4 which becomes effective as soon as the 200 pf capacitor (C1) across it is charged.

The collector of Q2 is directly coupled to the emitter-follower Q3. Output is taken between the emitter of Q3 and Z2, a zener diode with an average voltage of 4.7 v. This diode is selected so that Q3 is cut off when Q2 is on, thus limiting battery drain.

The output amplitude can be varied over two ranges by precision potentiometers R10 and R11, with zener Z3 (7.5 v) across the low range potentiometer to ensure that the low voltage range is independent of battery aging. Z3 also provides a low source impedance at low output voltages. The 1/16 amp fuse will open on output amplitudes above 50v if the output is short circuited. Shorts across the output at lower ranges will not affect the instrument. Lamp NE2

provides visual monitoring for pulses longer than a few msec.

Output voltage: 0 to 80 v peak.

Output pulse; Rise time < 5 μsec.

Output pulse duration: Equivalent to triggering pulse, from < 10 μsec min. to dc max.

Residual output potential between pulses is less than .01% output pulse voltage by component selection.

Capacitance from output terminals to ground approx 20 pf.

Transistors: Q1-Q2, 2N398; Q3, 2N1041.

Battery: 90 v; Current with S. I. U. on but not pulsed, 7.6 ma. Current drain during pulse, 15 ma.

Construction of the shielded input transformer T1 is described in detail in the source article.

Source: Mr. H. Fein, Department of Physiology, University of Utah, Salt Lake, Utah; also *The Review of Scientific Instruments*, October 1960.

MEDIUM HI-SPEED LINE DRIVER

Medium-power (under 1 watt) medium high speed switching is required in such computer functions as line drivers, memory-core drivers, power gates and pulse amplifiers. In all these circuits the switched current is in the general vicinity of 250 ma. Transistors for these applications must have desirable qualities at high collector currents; for example, h_{FE}, V_{sat}, V_{be} and T_{RE} (rise time constant) must show no abnormalities at high collector currents. Of these, V_{sat} is perhaps the most important because the power dissipation in a saturated circuit is $P_d = I_c \times V_{sat} = (I_c)^2 R_{sat}$.

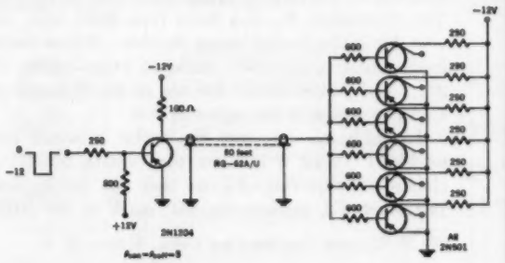


FIG. MADT 2 N1204 drives six 2 N105 transistors over coaxial cable.

Circuit Fig. 00 shows a Philco 2N1204 MADT driving six 2N501 inverters. Input to the 2N1204 is a negative 12-volt pulse. The 2N1204 is normally OFF with the 2N501 transistors all held in the saturated state. When the input pulse turns ON the 2N1204, its output, delayed by passing through 50 feet of RG-62A/U cable, turns OFF the six 2N501 inverters for a pulse duration determined by the delay line. The ratio of the switched collector current to the ON base current is equal in this case to the ratio of switched base current to the OFF base current, both being 5.

Source: Application Laboratory Report 691 "Transistor Guide for Switching Circuit Designers," Philco Corporation, Lansdale Div., Lansdale, Pa.

Continued on page 6

THERMISTOR THERMOMETER-ALARM

A convenient thermistor alarm circuit that may be used in testing the operation of laboratory electric ovens, heating appliances or as a household kitchen aid to signal when the roast is done, is given in Fig. 1. The thermistor R_t has a resistance of 10,000 ohms at a temperature of 25°C (76°F) and has a negative temperature-resistance coefficient. The potential of the base of Q1 therefore tends to rise as the temperature of the thermistor increases and its resistance falls. At a critical temperature, determined by the setting of potentiometer R1 (also the settings of calibration pots R5 and R7), Q1 conducts, which drives the base of Q2 more negative than its emitter and into conduction.

When Q2 conducts its collector becomes more positive, biasing diode D1 in the forward direction which causes V1 to conduct more heavily, so that both transistors are driven into saturation. The buzzer will sound and continue to operate until the supply voltage is turned off. For this reason, the alarm must always operate above ambient temperatures; that is, the circuit cannot be used to signal when a limiting temperature below ambient is reached.

R1 is a linear taper potentiometer, and the resistance values in the calibration circuit have been selected to provide a range over 140°F to 190°F. The thermistor, R_t, is a Veco type 41R1 unit, which may be solder-sealed using flexible—Teflon-insulated leads—in a small probe made of brass tubing (Fig. 2). Construction details for use as an electronic roast alarm are given in the source article.

To calibrate, immerse the probe in water heated to 140°F. Wait 3 minutes then rotate the R1 dial clockwise, adjusting R5 so that the alarm sounds just when R1 reaches the 140 mark at the lefthand

[1]T. M. Victory Engineering Corp., Union, N. J.

REVERSE RECOVERY TIME TEST CIRCUIT

A semiconductor diode does not exhibit its steady-state reverse resistance immediately when the bias conditions are suddenly changed from forward to reverse. The time required (Approx. 10^{-8} sec to 10^{-5} sec) for the resistance to recover to some predetermined value, called the reverse time, is an important specification in many applications of diodes.

The following circuit, a modification of the socalled IBM "Y" circuit, is recommended as a standard circuit for measurement of recovery times of 0.3 μsec and longer. A new standard is being prepared for measurement of faster recovery times. In use, the forward current level in the diode to be tested (D1) is established by the forward voltage supply B1 and the variable resistor R1. The impedance of the current supply is bypassed to ground by capacitor C1. The 6BC7 triple diode shunts the precision load resistor R5 during the period of forward current flow. Resistors R3 and R4 and battery B2 provide compensating bias for the contact potential of the 6BC7.

When a negative square wave is applied at the input jack, a reverse voltage is impressed on the series loop

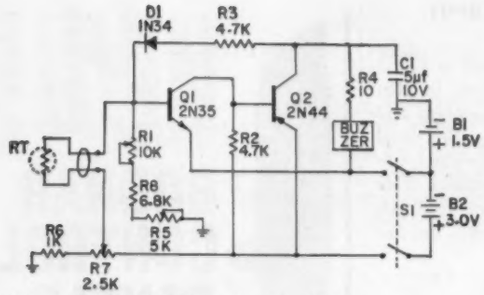


FIG. 1. **THERMISTOR** actuates alarm.

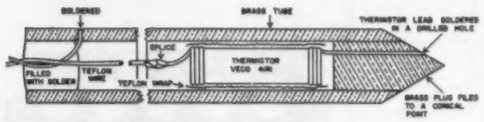


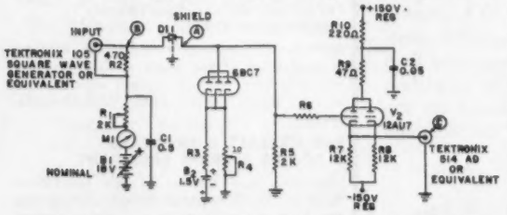
FIG. 2. **ROAST PROBE** construction.

end of the scale. If the buzzer does not sound, adjust R7 until it does. Repeat the process, with the probe in 190° water, adjusting R5 and R7 so that the alarm sounds when the dial is rotated clockwise to the 190° temperature mark. Since the R5 and R7 potentiometers interact, it may be necessary to repeat the process several times before the exact adjustment of both potentiometers is determined. Intermediate points on the R1 dial may be marked at the temperature for which it has been calibrated. All resistors are ¼ watt commercial grade, the buzzer is Johnson Model 114-400. The DPST switch is ganged to R1. All other values are shown on the diagram.

Source: "Electronic Roast Alarm" by Daniel P. Peters, 171 Reservoir Dr., Boonton, N. J., *Electronics World* June, 1960.

---

comprised of D1 and resistor R5. The 6BC7 is cut off by the negative plate-to-cathode voltage and the forward current supply is bypassed by C1. The reverse



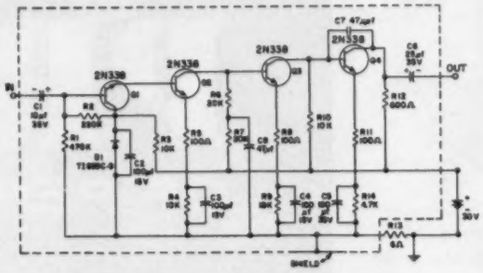
current is measured by observing the voltage across R5 during the period of reverse voltage. To decrease capacitive loading on R5, this voltage is coupled to the grid of the cathode follower V2, which has its output fed to a Tektronix 514AD or DuMont 329 oscilloscope or its equivalent.

(Calibration and measurement instructions are contained in EIA Std. No. RS-231 and NEMA Pub. No. SK500-1959, Reverse Recovery Time Measurement on Semiconductor Diodes, from Eng. Dept., Electronic Industries Association, 11 West 42nd St., New York 36, N. Y. or National Electrical Manufacturers Association, 155 East 44th St., New York 17, N. Y., Price $1.00)

Continued on page 8

VOLTAGE AMPLIFIER HAS HI-INPUT, LO-OUTPUT IMPEDANCE

The medium gain voltage amplifier circuit in Fig. 1 differs from the usual transistor amplifier in that its input impedance is approximately 8 megohms and its output impedance 600 ohms, reversing the usual high-gain, low-input impedence and high-output impedance characteristics of transistor amplifiers. This is accomplished through overall negative feedback provided by R_{17}. Resistors R_5, R_8, and R_{11} are individual stage feedback resistors. Bias resistors R_4, R_9 and R_4 which provide dc bias stability are bypassed by large capacity, low-voltage capacitors C_3, C_4 and C_5. Approximate dc has conditions of the transistors are given below.



Transistor	V_{ce}	I_E
Q_1	3v.	0.010 ma
Q_2	6	0.50
Q_3	13	0.59
Q_4	6	4.8

C_7 (47 pf) provides negative feedback from the collector to the base of Q_4 for high frequencies to prevent high frequency regeneration. This use of feedback also renders the circuit relatively independent of individual transistor parameters.

Chassis shield is connected to the circuit at the positive end of R_{13} instead of at the —30 v ground. This prevents bypassing R_{13} by the component-to-chassis capacity of the circuit, thus giving improved high frequency characteristics (Fig. 2) to the amplifier. NPN 2N338 silicon transistors were selected for the circuit. Input and output circuits use the common ground, which is insulated from the chassis.

Voltage gain: 40 db (100) from 25 cps to 50 kc.

Temperature Stability; Gain stable to ±0.10 db over the temperature range —55°C to 125°C.

Max. undistorted open circuit output: 1.8v rms.

Input impedance: Over 1 megohm from 25 cps to to 350 kc, over 8 megohm from 400 cps to 30 kc.

Noise Level: 24 μv equivalent input noise with input shorted, to 540 μv with input open.

Output Impedance: 600 ohms.

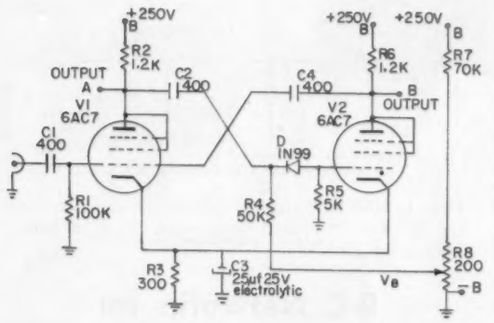
Frequency Response: ± db from 6 cps to 300 kc.

Power Supply: 30 v dc 6 ma regulated to ±3v

Source: Arthur D. Evans, Sr. Development Engineer, Semiconductor Components Div., in *Application Report Oct.* '58, Texas Instruments Incorporated, Dallas, Texas, also *Electronic Industries*, March 1959.

SENSITIVE MONOSTABLE MULTIVIBRATOR

The property of variable resistance with voltage, which is characteristic of semiconductor diodes, is used in the multivibrator circuit shown, in which the triggering sensitivity of a plate-to-grid coupled monostable multivibrator is improved approximately one-thousand times through the use of a low-capacitance point-contact diode.



POINT DIODE improves triggering sensitivity of multivibrator, although the circuit shows a Type IN99 diode, the author states "any point contact diode satisfying the requirement of low capacitance can be used."

The principle illustrated can be used to increase sensitivity of other conventional trigger circuits; the cathode-coupled version of the monostable multivibrator in particular having high threshold stability and independence from heater voltage variations. The point diode is favored over other diode types because it has low capacitance and high back resistance, and because high forward current capacity is not required. For maximum sensitivity and reliability in applications with varying ambient temperatures it may be necessary to regulate temperature or to compensate for temperature changes.

Component values are as shown in the circuit. All resistances can be ½ watt ±10%, capacitors are 600 v and values are in picofarads ($\mu\mu$f) unless otherwise marked. Sensitivity may be regulated by varying R8 with maximum sensitivity for stable operation from signals of approximately 1 millivolt. The time constant for duration of the quasi-stable or pulse state will be approximately

$$\tau = C_2 R_4 (R_D + R_5)/(R_4 + R_D + R_5)$$

where in this case $C_2 = 0.0004$ μf, R_4 is 50,000 ohms, R_D forward resistance of the diode is about 145,000 ohms and $R_5 = 5{,}000$ ohms, τ will have an approximate value of 80 μsec.

Source: Mirko M. Vojinovic, Institute of Nuclear Sciences "Boris Kidrich," Belgrade, Yugoslavia, also AIEE Transactions Paper 61-99," Design of Diode-Switch High Sensitivity Trigger Circuits," ,$1.00, AIEE, 33 West 39th St., New York 18, N. Y.

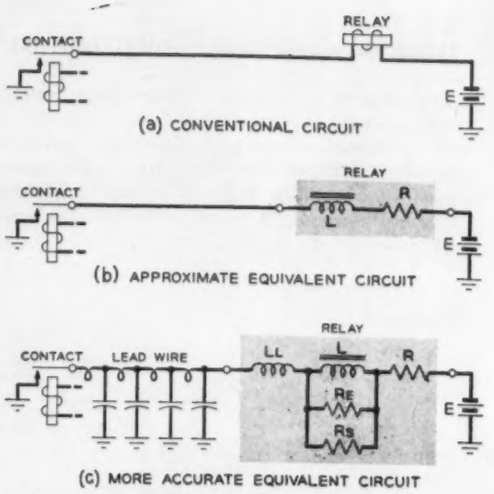


FIG. 1. SIMPLE circuit of (a) can be approximated by (b). For analytical purposes, (c) is a better equivalent circuit.

R-C Networks for Relay Contact Protection

To understand the function of the contact protection network, it is helpful to review the effect of a load circuit on an unprotected contact. Assume that current is flowing in the circuit of Fig. 1 (a). If, now, the contact opens, the circuit is broken and the current must drop to zero. However, the collapsing magnetic field in the inductance tends to keep the current flowing at the steady-state value. Since it cannot flow through the contacts, it flows to ground through the distributed capacitance of the lead wire, producing a transient voltage across the capacitance and thus across the open contacts.

At the first instant of contact opening, the voltage will rise at a rate of I/C volts per seond, where I is the steady-state current in amperes in the relay winding and C is the total capacitance of the lead wire in farads. When the contact voltage reaches the minimum sparking potential of air at about 300 volts, a spark occurs and the gap breaks down. A 15-volt arc discharge then takes place across the gap with a peak current limited only by the surge impedance of the cable and having a peak value of approximately

$$\frac{300 \text{ volts} - 15 \text{ volts}}{100 \text{ ohms}} = 2.85 \text{ amperes}$$

The arc will persist only for the fraction of a microsecond required to discharge the capacitance and then the process will repeat. The contacts at this instant still have only a minute separation. As they continue to separate, the voltage required to produce breakdown of the contact gap goes to higher and higher value, approaching 1,000 volts or more. The current in each arc discharge then has a peak value of 10 amperes or more. In Fig. 2(a) and 2(b), each charging of the capacitance appears as a line sloping upward to the right, but the discharges take place so quickly that no downward trace is evident. These high-current arc discharges, lasting for only a frac-

FIG. 2. OSCILLOGRAMS of transient voltages across unprotected contact when lead length is (a) 20 ft., (b) 60 ft. and (c) 400 ft.

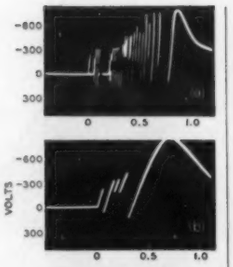
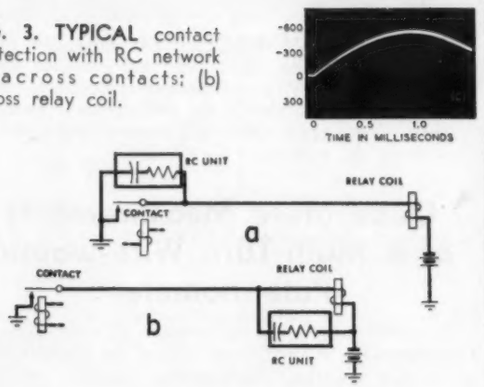


FIG. 3. TYPICAL contact protection with RC network (a) across contacts; (b) across relay coil.



tion of a microsecond, cause heavy contact erosion as the contacts open.

In Figure 1(c), with a 400-foot cable, the rate of voltage rise has been reduced so much that the voltage at any instant is always less than the breakdown threshold value for air at that separation and no breakdowns occur. The large cable capacitance now provides contact protection and the life of the relay contacts is therefore considerably prolonged. Where contact protection is needed, the wiring usually will not provide enough capacitance, so a capacitive protective network is commonly connected into the circuit. With few exceptions, a 0.1 μf capacitor is satisfactory for U- and AF-type relays.

With sufficient capacitance in the circuit for protection when the contact opens, a resistance is needed for protection when the contact closes. The network capacitor is charged to the full battery voltage when the circuit is open. Closing the contacts effectively short-circuits this voltage, so a resistance is connected in series with the network capacitor to limit the current through the contact. The resistor thus reduces erosion as the contact closes, but also tends to increase it as the contact opens. The sudden diversion of the steady-state current into the protection network on contact opening immediately produces a voltage across the contacts due to the current flowing through the protection resistance. A compromise, approximately equal to load resistance, is used.

A typical circuit of a 2,500-ohm relay with the 185A network, 0.1 mfd and 470 ohms, connected for contact protection is shown in Fig. 3a. An alternative connection of the RC unit is shown in Fig. 3(b).—(*From* 10-*page booklet "Rifa's RC Unit," including reprint of Bell Laboratories Record article, "Relay Contact Protection," Presin Co., Inc.,* 2014 *Broadway, Santa Monica, Calif.*)

FOR THIS LITERATURE CIRCLE 122 ON READER-SERVICE CARD

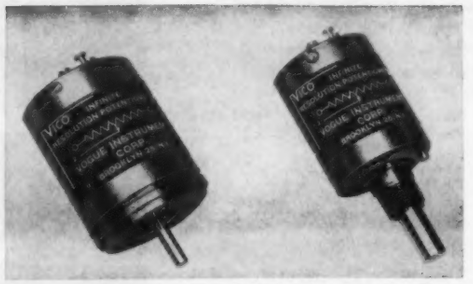


FIG. 1. **INFINITE RESOLUTION** wirewound potentiometer Model 106-S (left) has precision ball bearings and Size 10 servo mounting flange. Model 100A is identical electrically and physically except that it is equipped with sleeve bearings and mounts with 3/8"-32 bushing.

Quadrature Measurements of a Multi-Turn Wire-wound Potentiometer

In considering the ac performance of a precision potentiometer the induced phase shift of the output voltage is the most important characteristic. Another, and more commonly used method of expressing this characteristic, is the "quadrature" parameter. By quadrature is meant that component of the output voltage which is in quadrature—or 90° of out-of-phase—with the input voltage.

Although an ac-carrier servo-mechanism only responds to the in-phase component of signal voltage, quadrature may degrade the overall performance of the servo by saturating amplifiers, overheating servo motors, etc., in general causing sluggish response. Quadrature is, obviously, an undesired by-product of ac excitation.

In the conventional wirewound potentiometer, quadrature is principally due to the distributed capacitance between windings and the copper mandrel. Induced quadrature then becomes a function of wire size, nature of winding, overall resistance, geometry, shaft rotation, and excitation frequency. Quadrature plotted vs shaft rotation is roughly the shape of an "S" where quadrature is zero at the end points and the center, being positive or leading in the first 50% and negative or lagging in the second 50% of shaft rotation.

VICO infinite resolution wirewound potentiometers utilize a unique design in which a precious metal brush slides across a single helically-wound length of resistance wire. This resistance wire is supported on a non-metallic form of high dimensional stability and low thermal coefficient of expansion, which results in extremely high insulation resistance, low inductance and low capacitance when used in ac circuitry.

Quadrature measurements on the VICO potentiometer were taken at 400 cps using the test circuit shown. A standard ratio transformer with low phase-shift (10 micro-radians) was used to null the in-phase component of the potentiometer output voltage. The quadrature voltage was read directly on a sensitive phase-sensitive carrier-tuned VTVM. A bridge transformer was used as a summing device and to increase sensitivity.

Although quadrature for a conventional 2" potenti-

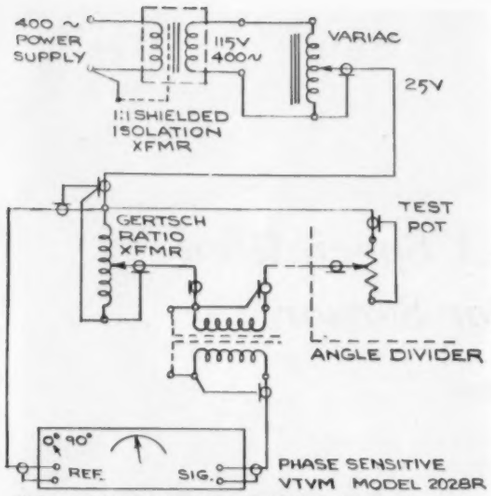


FIG. 2. QUADRATURE MEASUREMENT schematic used in test of VICO Model 106S 1000 ohm Potentiometer.

ometer at 400 cps may be expected to be about 0.1 mv/volt/1000 ohms, the specification for the VICO potentiometer is realistically judged to be 0.0004 mv/volt/-1000 ohms, or at least 250 times less than that for a conventional potentiometer. (*From 4-page engineering study on VICO Models 106S and 100A Infinite Resolution Potentiometers, prepared by Engineering Information Associates, Inc., for Vogue Instrument Corporation,* 2350 *Linden Blvd., Brooklyn* 8, *N. Y.*)

FOR THIS LITERATURE CIRCLE 123 ON READER-SERVICE CARD

Liquid System Tester

New self-contained, portable Quan-Test, Model TF-20, a servo-operated Tester for capacitance-type gage systems, provides a built-in calibration for *both* sensing and indicating component readings. Combines Model MD-2A Probe Tester with a newly-designed,

integral Indicator Test Unit. Probe capacitances from 0-5,000$\mu\mu$f are measured by a servo-actuated capacitance bridge. Indicator test unit simulates probe values by fixed and adjustable capacitors, with compensator values adjustable from 25-250$\mu\mu$f. Accuracy of either unit is $\pm$0.15% of full scale.—*Conair* (*Consolidated Airborne Systems, Inc.*) 900 *Third Ave., New Hyde Park, N. Y.*

FOR THIS LITERATURE CIRCLE 124 ON READER-SERVICE CARD

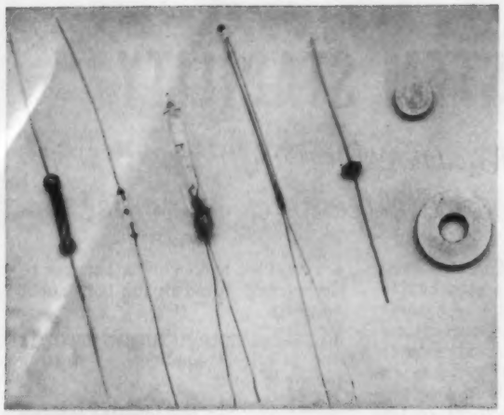


FIG. 1. THERMISTORS, temperature-sensitive resistors, are made in a wide range of styles and have an even wider range of electrical characteristics. A few representative VECO high-reliability types are shown.

The Thermistor--A Specialized Semiconductor Sensor

MEYER SAPOFF

The accompanying article on basic thermistor considerations has been prepared for MILITARY SYSTEMS DESIGN by Mr. Meyer Sapoff with a view to provide better basic understanding of thermistor behavior. Mr. Sapoff, Director of Research and Engineering for the Victory Engineering Corporation of Union, N. J. has had wide experience in semiconductor research and development and is the author of numerous articles covering mathematics, physics and special developments. Victory Engineering Corporation was organized to manufacture thermistors and varistors under a cross-licensing agreement with the Bell Telephone Company Laboratories and Western Electric Co.

THE THERMISTOR, a temperature-sensitive element of amazing versatility, is finding increasing applications in electronic military and industrial systems. In its simplest form it is a tiny ceramic bead fired between almost invisible parallel platinum wires, although it may also be encapsulated in glass or made in rod, disc or washer configurations (Fig. 1).

The nonlinear nature of the negative temperature-resistance characteristic of the thermistor is evident from the family of curves in Fig. 2 of six probe-type VECO thermistors. By varying the ceramic formulation and size of bead, an almost infinite variation in characteristic slope is possible (Fig. 3).

Another variable is the thermal time-constant, governed by the rate at which heat is transferred from or to the thermistor in any application.

Self-heating of a thermistor by the current flowing through it is still another factor tending to complicate design problems involving thermistor applications.

To better understand the nonlinear behavior of the thermistor over a wide range of conditions, the applications engineer does well to study its action in the light of modern semiconductor theory, which closely parallels that of transistors and diodes in many important aspects.

A thermistor (thûr-mĭs'ter) is a "thermally sensitive resistor whose primary function is to exhibit a change in electrical resistance with a change in body temperature".[1] In the main, the discussion which follows will be limited to thermistors that are hard, ceramic-like, oxide semiconductors which exhibit relatively large negative temperature coefficients of resistance. At present, the major part of the thermistor industry deals with this type of device.

Types of Semiconductors

Solid materials can be classified into three major groups in accordance with their ability to conduct electricity—conductors, semiconductors and insulators. Although no sharp boundaries exist between these groups, a division can be made arbitrarily in terms of the resistivities of the materials. Conductors have specific resistances which are less than 0.1 ohm-cm, semiconductors are characterized by specific resistance values at room temperature between 0.1 and 10^9 ohm-cm while the resistivity of insulators is considered to be greater than 10^9 ohm centimeter.[2]

Semiconductors may be further classified in accordance with their major current carriers as ionic, electronic or mixed conductors[3]. Ionic semiconductors include chlorides and some sulphides. Mixed semiconductors include other sulphides and a few oxides, such as uranium oxide. Ionic and mixed conductors have the undesirable property of ion transportation through the solid and consequently and are rarely used for thermistors. The majority of commercial thermistors are made from electronic semiconductors which include most oxides such as Mn_3O_4,

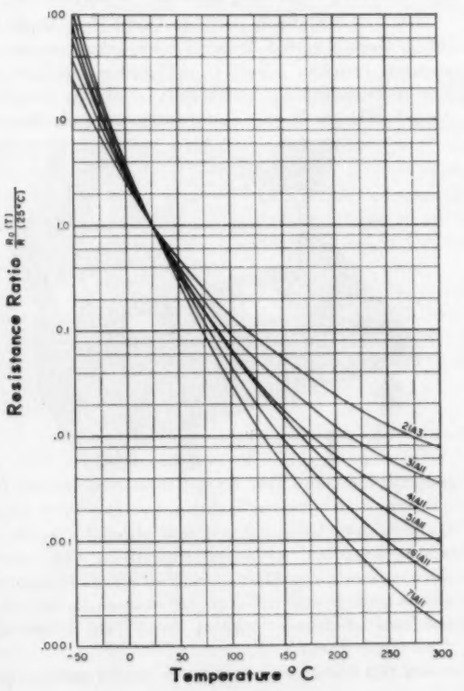


FIG. 2. RESISTANCE-TEMPERATURE Characteristics of six probe-type thermistors, which comprise the VECO KP50 kit. Selections of thermistors in kits covering a range of characteristics provide designers with a practical method for choosing a standard thermistor or for specifying a special unit.

FIG. 3. SKILL plus ultra-pure materials are required to fabricate the high-reliability thermistors required in military and other critical electronic systems.

Fe_2O_3, NiO, CoO; carbides such as SiC and elements such as germanium and silicon.

Intrinsic vs. Extrinsic Semiconduction

There are two basic types of semiconduction—namely, intrinsic and extrinsic. If a number of samples of a semiconductor such as germanium, having various degrees of impurity, were examined with respect to their conductivity vs absolute temperature characteristics, it would be found that at high temperatures all the samples would exhibit nearly the same conductivity. At low temperatures, the samples would show wide variations in conductivity and their conductivity would be found to increase with increasing amounts of impurity. The conduction which occurs at high temperatures is called *intrinsic* conduction since it appears to be an intrinsic property of the semi-conductor. In the low temperature region the germanium would be said to be an impurity semiconductor and the conduction which occurs is referred to as *extrinsic* conduction.

An intrinsic semiconductor is one which conducts in the pure state. If the semiconductor is completely free of impurities, such as would be the case for extremely pure monocrystalline germanium or silicon, then only intrinsic conduction occurs and, for a specified applied electric field, the conduction will increase in a predictable manner with increasing temperature.

Energy Band Theory of Electron Movement

The mechanism of conduction in semiconductors can best be understood from a consideration of the energy band theory of quantum mechanics. Quantum theory predicts that the electrons in a free atom must exist within discrete energy levels which are separated by "forbidden" gaps and that only one electron can occupy a particular energy state in any system. If an electric field acting on an electron has the correct magnitude, it will cause the electron to jump across a forbidden gap to an unoccupied allowed level.

This same type of behavior exists in a solid body in which electrons move between the atoms in the body. Although every atom within a solid has its own discrete energy levels, the interaction of the atoms results in allowable energy bands which are separated by forbidden or unallowed energy bands. Under the influence of an electric field, conduction in a solid occurs when electrons move within allowed energy bands which are not completely filled. In a perfect insulator, all of the allowed energy

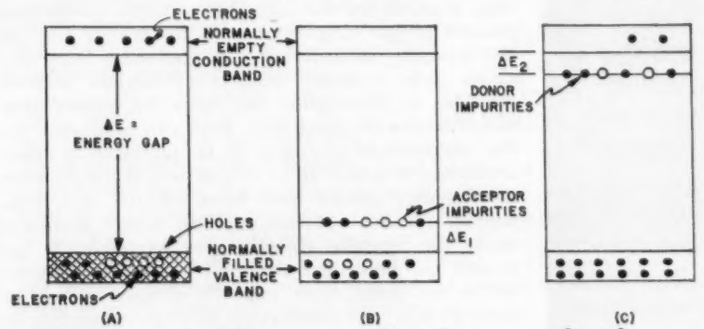


FIG. 4. QUANTUM ENERGY requirement for conduction: (a) shows **intrinsic** conduction in which electrons are activated into conduction band by thermal energy leaving "holes" behind; (b) **extrinsic p-type** conduction is typical of oxide semiconductors in which Schottky defects exist while (c) shows **extrinsic n-type** conduction in oxide semiconductors in which Frenkel defects predominate.

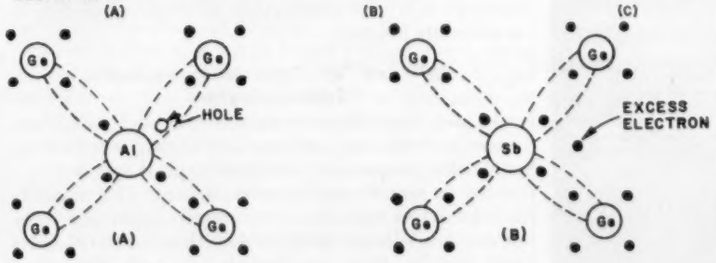


FIG. 5. DOPING of Germanium. (a) Aluminum, an "acceptor" impurity with three valence electrons forms covalent bonds with four Ge atoms, but one bond lacks electron (has "hole"), forming "p" type semiconductor. (b) Antimony, a "donor" impurity with five valence electrons, also forms covalent bonds with four Ge atoms, but has excess electron, creating "n" type semiconductor material.

bands are either completely filled or completely empty. The same is true of an imperfect insulator or a semiconductor at a temperature of absolute zero. In this case the valence electrons occupy all of the allowed energy states in the highest filled band. As the temperature of such solids is raised above absolute zero, some of the electrons from the valence band acquire sufficient energy to jump across the adjacent forbidden band into the lowest allowed empty band and some electronic conduction occurs under the influence of an electric field.

For every electron that is "activated" into the normally empty conduction band there is left behind a "hole" in the normally filled valence band. This permits other electrons having slightly lower energies to move within the valence band into these holes under the influence of the applied electric field. These holes behave, under the influence of the applied field, like particles which have a charge equal and opposite in sign to that of an electron and a mass equal to or somewhat larger than the mass of an electron.[4, 5] Both electrons and holes contribute to the conductivity of an intrinsic semiconductor in approximately equal amounts. The mechanism by which thermal activation results in conduction of electrons and holes in an intrinsic semiconductor is illustrated in Fig. 4. The activation energy, ΔE, associated with the forbidden gap can be used as a more refined means of classifying solids in accordance with their electrical conduction properties. A solid material which has an energy gap in the range of 0.1 to 1.5 electron volts (ev), may be considered to be a semiconductor.[3] The energy gap for conductors is either non-existent or less than 0.1 ev while that for insulators is greater than 1.5 ev.

Extrinsic conduction results from chemical impurities in the solid solution or lattice defects in the semiconductor. These imperfections result in extra energy levels which lie in the normally forbidden band. This accounts for the fact that extrinsic conduction prevails at low temperatures. As the temperature of the impurity semiconductor is increased from absolute zero, a greater number of carriers become available by dissociation from impurity centers than would otherwise occur for a pure semiconductor. As the temperature continues to be increased a point is reached at which all of the carriers available from the impurity centers have been released, and their number remains constant. At still higher temperatures, the intrinsic electrons are available in far greater numbers than the total number of carriers which are freed from impurity centers and as a consequence, the conduction at high temperatures is primarily intrinsic.

"N" and "P" Type Monocrystalline Semiconductors

In monocrystalline semiconductors, such as Germanium and Silicon, extrinsic conduction results from controlled amounts of chemical impurities which are added to the otherwise pure element. The impurity is selected so that its atoms contain either one more or one less valence electron than those of the element and thereby form covalent bonds with the atoms

of the element. This is illustrated symbolically in Fig. 5. In Fig. 5 (a) an aluminum atom is shown forming four covalent bonds with neighboring germanium atoms. Since aluminum has three valence electrons and germanium has four valence electrons, each aluminum atom which appears in the germanium lattice structure contributes a hole to the lattice structure. Impurities which contribute holes are called "acceptor" impurities and semiconductors which contain added acceptors are called "p-type" semiconductors because its extrinsic conduction is due to a predominance of positive carriers.

Fig. 5 (b) shows a germanium crystal "doped" with antimony which has five valence electrons. Since the antimony atoms contribute excess electrons in the germanium lattice structure, the antimony is referred to as a "donor" impurity. The extrinsic conduction which results from donor impurities is due primarily to negative carriers. Accordingly, such semiconductors are called "n-type" semiconductors.

Oxide Type Semiconductors

Although the structure and mechanism of conduction in monocrystalline semiconductors is fairly well understood, their use as thermistors has been very limited, to date. At present, almost all commercial thermistors are fabricated from oxide semiconductors. Unfortunately, no quantitative theory presently exists which adequately explains the behavior of oxide semiconductors. However, some qualitative insight may be obtained by comparing the properties of oxide semiconductors with those of single-crystal doped elements.

Whereas conduction in monocrystalline semiconductors depends on chemical impurities, the atoms of which form covalent bonds with those of the crystal, conduction in oxide semiconductors depends primarily on physical imperfections. In addition to covalent bonds, the bonds between the atoms of oxide semiconductors are also ionic.

There are two types of lattice defects in oxide semiconductors which are comparable to the donor and acceptor impurities of monocrystalline semiconductors and result in excess electrons or holes.

In one type of oxide semiconductor, there are empty impurity levels which lie in the forbidden gap just above the normally filled valence band. When electrons are raised from the filled band into the impurity levels, the resulting holes give rise to conduction in the valence band (Fig. 46). Oxides of this type, such as NiO and Cu_2O are called "p"-type oxide semiconductors. The impurity levels result from *Schottky* defects in which positively ionized divalent metal atoms are missing from the lattice as a result of an excess of oxygen.

Frenkel defects result in excess ionized metal atoms in the lattice which are not bound to oxygen atoms. Defects of this type are due to a deficiency of oxygen. The electrons associated with the excess metal atoms result in impurity levels just below the conduction band comparable to donor levels (see Fig. 4c). Since the extrinsic conduction is due to electrons which are raised from the impurity level into the conduction band, materials of this type are

Book Review

INFORMATION RETRIEVAL AND MACHINE TRANSLATION, Part I, edited by Allen Kent (1961), Interscience Publishers, Inc., 250 Fifth Ave., New York 1, N. Y., 686 p., 6" x 9", $23.00. Based on Int. Conf. for Standards on a Common Language for Machine Searching and Translation, Western Reserve Univ., Cleveland, Ohio, Sept. 1959. Part II to follow.

called "n"-type oxide semiconductors. Examples of n-type oxides are ZnO and TiO_2.

Historical Development of Reliable Thermistors

The thermal behavior of semiconductors is by no means a new phenomenon. As early as 1837, Michael Faraday reported measurements on the high negative temperature coefficient of silver sulphide.

The first commercial production of thermistors was begun in Berlin, Germany, by the Orsam Company in 1932 and by 1939 this company had produced over ten million units of 90 different types.[6] Between the mid-thirties and early forties thermistors were produced and mentioned in the literature abroad in Germany, Holland, Russia, England and Japan. Commercial production of thermistors in the U.S.A. was begun in the mid 1930's.

The greatest contribution to the early development and manufacture of thermistors resulted from research conducted at the Bell Telephone Laboratories. During the early thirties the Bell Telephone Laboratories were confronted with the problem of developing a device which would compensate for the variation of resistance of telephone transmission lines with temperature. Although a large number of potentially suitable semiconductors were initially investigated, they found it necessary, after several years of research and development, to eliminate all but a few carefully selected basic materials which were found to exhibit chemically and electrically stable characteristics. The major difficulty experienced with most of the metallic oxides considered lies in producing them with stable characteristics which are reproducible to fixed specifications and free from undesirable effects such as polarization.

The development of thermistors at the Bell Telephone Laboratories was further stimulated by the requirements for such devices during World War II and by 1945 thermistors had found wide-scale telephone usage.

Some early types of thermistors manufactured by the Western Electric Company for time delay applications in telephone circuits made use of uranium oxide. Although these were suitable for use in ac circuits they could not be used in dc circuits because of the polarization effect exhibited by uranium oxide. To eliminate this undesirable property, most thermistors subsequently developed by the Bell Telephone Laboratories and manufactured by the Western Electric Company were made from two basic oxide systems which were found to exhibit the most stable characteristics. These are their material No. 1 which consists of oxides of manganese and nickel and exhibits a temperature coefficient of −4.4%° C and a resistivity of approximately 2100 ohm-cm at 25° C; and material No. 2 which is comprised of oxides of manganese, nickel and cobalt and has a temperature coefficient and resistivity at 25° C of −3.9%/° C and approximately 300 ohm-cm respectively.

Although the improper use of other types of commercially available thermistors, designed for less critical applications, has impeded the growth of the thermistor industry to an appreciable extent, the outstanding record established by the Western Electric Company and other organizations licensed by them

to manufacture thermistors made of these materials has proven beyond any doubt that thermistors are capable of meeting the very high reliability requirements demanded of telephone and other electronic circuit components. In recent years, thermistors of this type have been used in almost every missile, rocket and satellite program carried on in this country.

Besides the Western Electric Company, an organization which has provided outstanding contributions to the continued development of the type of thermistor originally developed by the Bell Telephone Laboratories, is the Victory Engineering Corporation. As a result of their pioneering efforts in the manufacture of high quality thermistors and the education of industry in the proper use of high-quality reliable thermistors, the Victory Engineering Corporation has expanded the original Western Electric Company line of thermistors limited primarily to telephone circuit and bolometry usage to a standard line which includes more than 600 cataloged, stock items for use in over 100 standard applications as well as countless other types for specific applications.[8,9]

References

1. Electronic Industries Association, P 1.6 Working Group on Thermistors and Varistors, tentatively approved definition.
2. Scarr, R. W. A. and Setterington, R. A., "Thermistors, Their Theory, Manufacture and Application", The Institution of Electrical Engineers, Paper No. 3176M, Jan., 1960.
3. Becker, J. A., Green, C. B. & Pearson, G. L., "Properties Uses of Thermistors—Thermally Sensitive Resistors", Bell Telephone System Monograph B-1443; Trans. AIEE Vol. 65, pp. 711-725, Nov. 1946; B.S.T.J. Vol 26, pp. 170-212, Jan. 1947.
4. Wilson, A. H., "Semiconductors and Metals", The University Press, Cambridge, England, 1939.
5. Seitz, F., "The Modern Theory of Solids", McGraw-Hill Book Co., New York, New York, 1940.
6. Weise, E. K., Jentschke, W. and Robinson, T. W., "Thermistors As Tools in Research and Development", U.S.A.F. Technical Report No. 5824, Sept. 1949.
7. Dowell, K. P., "Thermistors as Components Open Product Design Horizons", Electrical Manufacturing, August, 1948.
8. VECO Data Book, V 42, Victory Engineering Corporation, 1959.
9. Technical Catalog of VECO Products, Victory Engineering Corporation, latest edition.

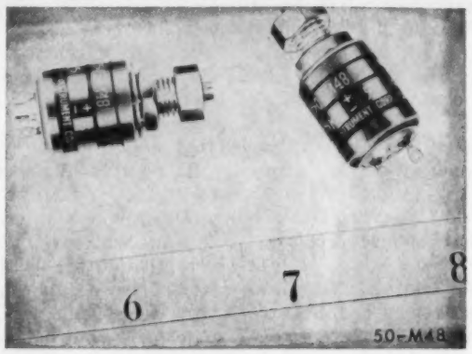
BOOK REVIEWS

TRANSISTOR LOGIC CIRCUITS, by Richard B. Hurley (1961), John Wiley & Sons, Inc., New York 16, N. Y. 363 p., 6″ x 9″, $10.00. Covers logical mathematics, logical routines and blocks, and transistor circuits that implement the mathematics and blocks.

PARTIAL DIFFERENTIAL EQUATIONS and **CONTINUUM MECHANICS,** edited by Rudolph E. Langer (1961), The University of Wisconsin Press, Madison, Wis., 397 p., 6″ x 9″, $5.00. Consists of 19 lectures delivered at an international conference at the Mathematics Research Center, Univ. of Wis., June 7-15, 1960; also abstracts of 45 papers presented at this conference.

New Miniature Pot Trimmer Qualifies Under Stringent Mil Specs

The precision wirewound potentiometer, 50-M48, is expressly designed and built to meet the most stringent requirements of Mil-R-27208 (USAF), style RT140A3M2T. A hermetically sealed cover is sol-



dered to the housing and the shaft is sealed with a silicone rubber "O" ring. A split type bushing with locknut assures permanent setting. The variable resistor is available in stock in standard resistance values of 25, 50, 100, 250, 500, 1K, 2K, 2.5K, 5K and 10K ohms. Standard resistance tolerance is ±5%. Special resistance values and tolerances are available on request. The antirotation pin, shaft and hardware are of 303 stainless steel.

The 50-M48 will meet or exceed the following environmental specifications:

1. Temperature coefficient: ±.005%/degree C.
2. Power Dissipation: 1 watt at 125°C for 1500 hours.
3. Temperature range: —55° to 200°C per MIL-STD-202 Method 102.
4. Dielectric strength: 1000 vac for one minute.
5. Moisture: MIL-STD-202, Method 106A.
6. Vibration range: 10 to 2000 cps per MIL-STD-202 Method 204.
7. Shock: 50G, MIL-STD-202, Method 203.
8. Stop torque strength: 6 lb-in.
9. Rotational life: 1500 cycles.
10. Salt spray: MIL-STD-202A, Method 101.

(*From 48-page catalog, Precision Wirewound Potentiometers, Maurey Instrument Corp.*, 7917 *So. Exchange Ave., Chicago* 17, *Ill.*)

FOR THIS LITERATURE CIRCLE 128 ON READER-SERVICE CARD

BOOK REVIEW

DATA BOOK—THERMISTORS AND VARISTORS, Victory Engineering Corp., Springfield Road, Union, N. J. (1959) 39 p., 5½" x 8½", $1.00. Theory and application data on Thermistors and Varistors manufactured by Victory Engineering under Bell Telephone Lab. and Western Electric Co. licenses.

FOR MORE INFORMATION CIRCLE 372 ON READER-SERVICE CARD

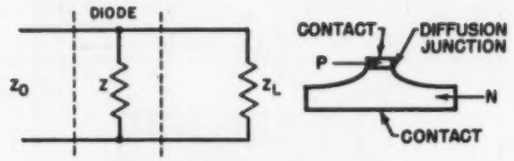


FIG. 1. SHUNT DIODE switch schematic.

Solid State Control of Microwaves

DR. RICHARD W. DAMON

Microwave Associates, Inc., Burlington, Mass.

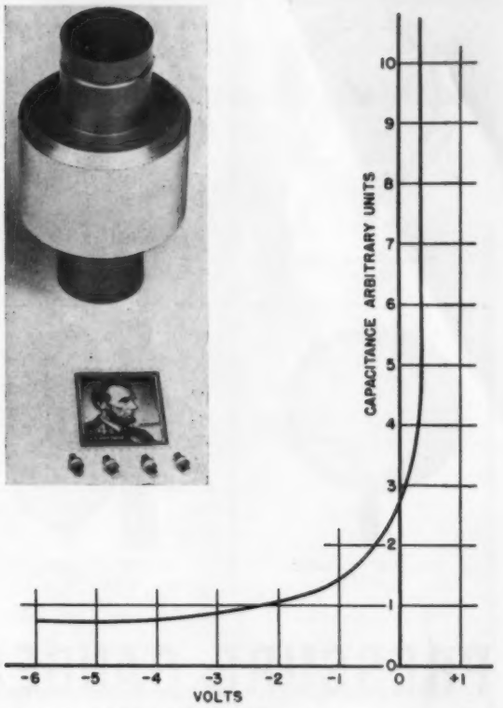


FIG. 2. DIODE VARACTOR Capacitance vs Bias Voltage. Typical diode varactor is shown in the inset in enlarged view and with actual units compared with postage stamp.

MOST publicity attending advances in solid state electronics has emphasized the transistor. Not so glamorous, perhaps, the semiconductor junction diode has found great utility as a power rectifier and as a fast switch for computer applications, and the importance of point contact diodes for microwave detection is also well recognized. More recently, it has been found that semiconductor diodes also are extremely useful for the control of microwave energy and permit the construction of novel types of switches, phase shifters, duplexers, and other microwave components. These components provide the reliability of solid state devices required in today's complex electronic systems; they have the speed of operation necessary for high transmission rate communication systems; they are light and compact for airborne and missile applications.

Typical performance capabilities of available solid state devices are as follows:

1. *Switches*: Switches having bandwidths of from 5% to over an octave have been constructed with power handling capability of 150-watts peak and several watts CW. Frequency of operation of these switches is from 100 mc to 12,000 mc, and the switches have been constructed in both coaxial line and waveguide. Special switches have been constructed which can handle up to 10 kw peak power.

2. *Limiters*: Power limiters have been constructed with bandwidths of from 5% to 30% having power capability of 5 kw peak, and 30 watts CW. Output power is limited to safe levels for detector crystals. Frequency of operation of these devices has been from 100 to 3000 mc.

3. *Duplexers*: Duplexers having bandwidths of from 5% to 20% with power handling capabilities of 10 kw peak and 30 watts CW have been built. Frequency of operation of these devices is from 200 to 1500 mc.

When a diode is inserted in series or in shunt with a transmission line, RF power incident on the diode is reflected by, absorbed in, or transmitted past the diode. As an example, consider a switch which utilizes a variable reactance type diode (varactor)[1] in shunt with a coaxial line. As shown in Fig. 1, if the diode exhibits high impedance it has little effect on the power transmitted to the load. For an impedance, Z, the insertion loss (I.L.) obtained with the generator and the load matched to the characteristic impedance of the line is

$$\text{I.L.} = 1 + \frac{Z_0^2}{2Z} \qquad (1)$$

Note[1]

A varactor diode is a p-n junction diode in which the depletion layer is the dielectric of the capicator. Since the thickness of the depletion layer depends on the voltage applied to the junction, its capacitance is readily controlled. Ideally the internal resistance of the varactor (in series with the capacitor) must be as low as possible, the forward and reverse conduction must be small in the voltage range used, and the capacitance must change with negligible delay.

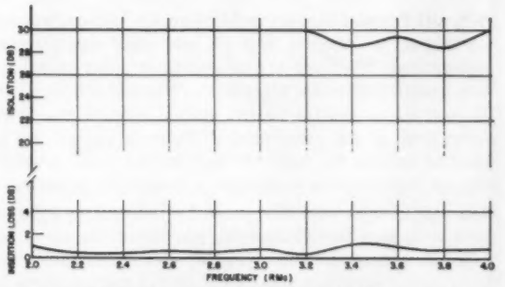


FIG. 3. SPST S-BAND Diode Switch Characteristics, Isolation and Insertion Loss (db) vs Frequency.

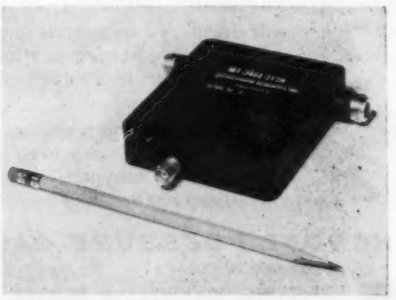


FIG. 4. HIGH SPEED All-Solid-State Coaxial Switch MA-3464 is typical of new medium power microwave switches to be exhibited at WESCON.

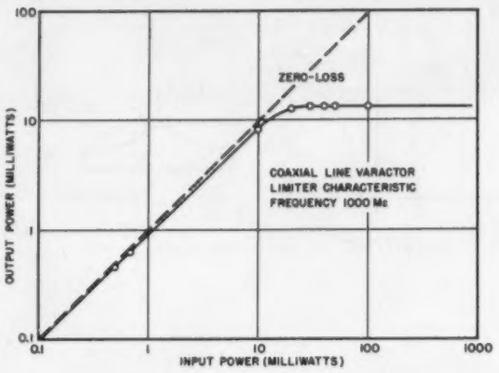


FIG. 5. COAXIAL LINE Varactor Limited Characteristic Frequency 1000 mc.

The switching properties of the network can be evaluated by inserting into Equation (1) the appropriate impedance values for the diode network in both the "on" and "off" conditions. A typical diode capacitance-voltage characteristic is shown in Fig. 2. Under forward bias conditions, the diode exhibits a large capacitance and resulting low reactance; thus most of the power is reflected because the diode impendance is much less than the load impedance. Under reverse bias conditions, the diode exhibits a small capacitance, or a high reactive impedance, allowing the power to be transmitted to the load with small loss.

Fig. 3 shows the performance characteristics of a typical broadband switch for a device operating at S-band. Within the range of operation of the diode switches, they offer significant advantages over other devices. Most striking is the switching speed, which is on the order of nanoseconds. These switches are characterized by very small size and light weight, and the driving power to obtain switching action is only tens of milliwatts (Fig. 4). Thus, multiple-throw switches requiring relatively modest switching power and with light weight and small size become feasible.

The varactor diode exhibits a change in impedance in response to an applied RF voltage, in addition to the dependance on applied DC voltage. Thus, the diode impedance changes as a function of RF power level. By placing such a diode in shunt across a transmission line, a limiter can be constructed having characteristics as shown in Fig. 5. At low power levels, the varactor reactance is tuned with a shunt inductance and presents a very high impedance across the line; thus, the insertion loss is very small. At power levels above a few milliwatts the diode capacitance increases (decreasing the shunt impedance) and the insertion loss increases with increasing power. This maintains the power output essentially constant. This simple limiter is of great value as a receiver protector.

The varactor power limiter, similar to the semiconductor switch, operates by reflecting the incident

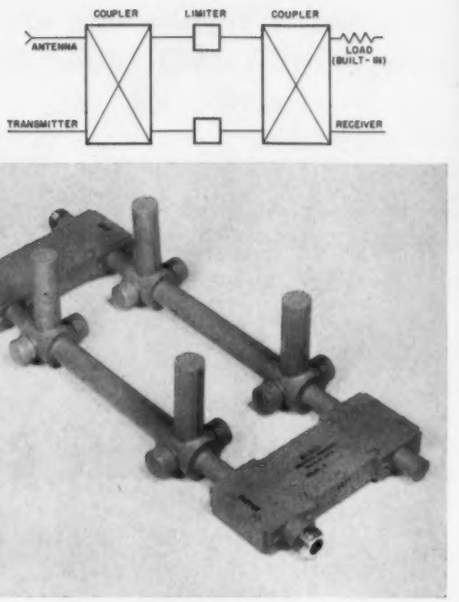


FIG. 6. SOLID-STATE DIODE Duplexer MA-3475. Schematic diagram is shown above.

power. This makes possible the construction of a complete solid state duplexer by utilizing a circuit such as that shown in Fig. 6a. At high power levels, the varactor diode reflects the transmitter power and the output emerges from the antenna terminals. The low power received by the antenna passes through the shunt diodes with low loss and emerges at the receiver terminals.

This technique permits the construction of completely solid state duplexers of very light weight and fast response.

The devices described here are only representative of the many new components which can be constructed with the help of new semiconductor technology. These devices have already found an important place in electronic systems as substitutes or replacements for mechanical switches and gas devices. In some cases, equivalent performance could not be obtained with previously existing devices. Many will be on display at the Microwave Associates booth at Wescon 61.

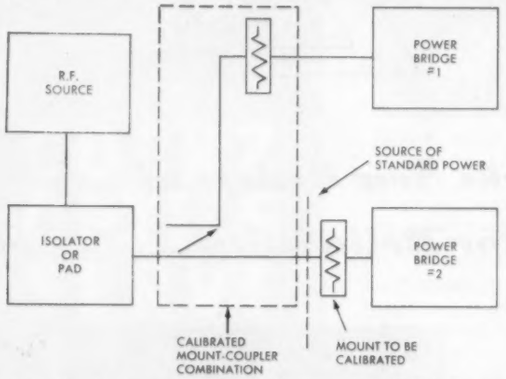
FOR MORE INFORMATION CIRCLE 129 ON READER-SERVICE CARD

REACTIVE COMPONENTS

will undergo special scrutiny in the editorial pages of the September-October issue of MSD. Ad closing date for this special-emphasis issue —October 1.

Bolometer Mount Calibration

Bolometers used in Microwave power measurements fall into two categories, thermistors and barretters. Barretters have a positive temperature coefficient of resistance, a short thermal time constant (typically 120 microseconds) and can tolerate only moderate overloads. Thermistors on the other hand exhibit a negative temperature coefficient of resistance, a long thermal time constant (in the order of 0.1 second) and are much more tolerant



of overloads than are barretters. Because of their longer time constant, thermistors are more suitable for the measurement of the average value of pulse power. This feature coupled with this greater tolerance for overload make them the preferred type for RF power measurements in most applications. Barretters are used as precise square law detectors and in sensitive measurements at low power.

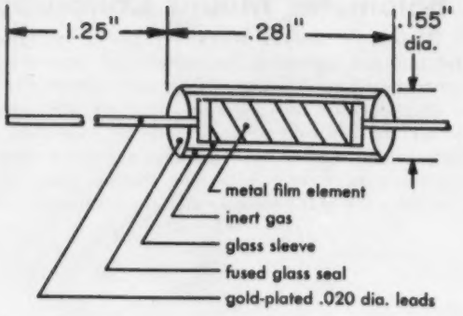
The errors associated with the bolometer and its mount are usually lumped together and expressed as a calibration factor. The bolometer mount is often attached to the side arm of a directional coupler with a coupling of 3 db, and the calibration factor determined for the combination in which case it is defined as the ratio of the dc substituted power in the bolometer to the RF power incident on a non-reflecting termination attached to the main arm of the directional coupler (see Figure). Power Bridge #1 is used to measure the substituted power in the bolometer mount on the directional coupler side arm. Application of the known calibration factor then gives the RF power incident on the mount to be calibrated. The ratio of the dc substituted power in this bolometer to the RF power incident on the mount is then the calibration factor of the mount being calibrated.

Where possible, the mount-coupler combination should be calibrated at the National Bureau of Standards so that the calibration factor is known to the highest possible accuracy. The accuracy given by the National Bureau of Standards for this calibration in X-band is $\pm 1\%$ at the present time. Since the National Bureau of Standards does not offer this service at all frequencies, Weinschel Engineering has established a limited service to supplement that of the National Bureau of Standards in 50 ohm coaxial line ("N" connector) between 100 and 1500 megacycles. An accuracy of 2% is given for these calibrations at the present time.—(*From 12-page bulletin, "R.F. Power Bridges and Thermistor Mounts", Weinschel Engineering, Kensington, Md.*)

FOR THIS LITERATURE CIRCLE 130 ON READER-SERVICE CARD

ACTUAL SIZE

FIG. 1. MINIATURE Resistor is distinguished for its high reliability and for being the smallest glass-encapsulated Mil-Spec unit in production.



MINUTEMAN Sparks New Orders of Miniature Resistor Reliability

MINIATURE RESISTORS which are fault-free to a degree of reliability several orders higher than any other known "high reliability" resistor, are a result of the Air Force's MINUTEMAN Missile program. A new high-reliability fixed metal film resistor has been developed by the International Resistance Company of Philadelphia, Pa., under research, testing and production contracts totalling nearly $2.5 million. IRC is a sub-contractor to Autonetics Div. of North American Aviation, prime contractor for the Minuteman guidance program.

The Air Force demanded that resistors for MINUTEMAN must function so faultlessly that a failure would be permitted only once in 250 million unit hours of operation. Resistors meeting these and other stringent specifications are now in full production and are available for use in other military applications. International Resistance Company officials predict that the new resistors will influence the standards of the entire electronics industry.

The new component is an evaporated metal film type resistor (Fig. 1) of completely inorganic construction, hermetically sealed in glass (0.155" diameter x 0.281" long), and rated at ⅛th watt at 125° C continuous operation, derating to zero at 165° C. Some idea of the difficulties in quality control of the manufacture of so small and vital a component is gained from Fig. 2, in which a completed resistor is held by a control laboratory worker preparatory to closer scrutiny under the binocular microscope. Advanced methods of film deposition (Fig. 3) carefully control the purity of materials as well as the temperature, potentials and atmosphere at which deposition is made.

No effort is spared to control and document all factors affecting the reliability objective. This goal, equal to a failure rate of 0.0004%/1,000 hrs, will be supported by tests of 4,000 hours each on 65,000 units, a total of 260 million unit test hours.

Advanced manufacturing techniques such as dust-free ultra-clean rooms, where humidity and tempera-

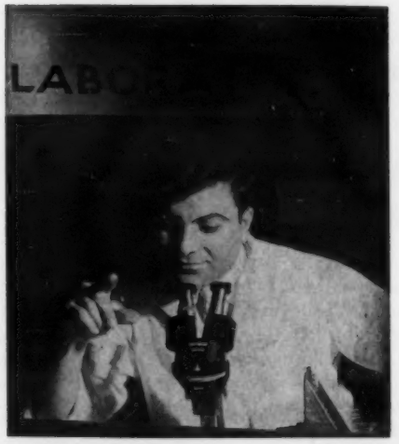


FIG. 2. QUALITY CONTROL of new resistor requires special tests, automatic equipment.

FIG. 3. ADVANCED Film Deposition techniques carried on in "Clean Room" environment are used to carefully control metal resistive film.

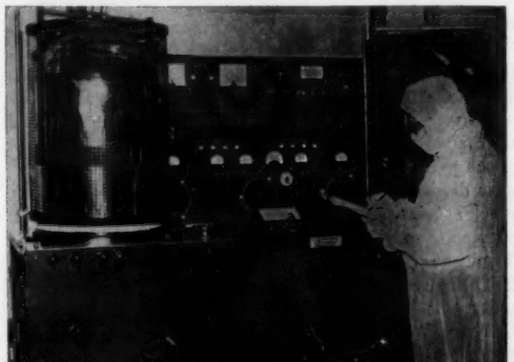


FIG. 4. PERSONAL HISTORY of each unit is documented to provide clues to further "improve the breed." Raw materials, process variables, etc., are made available in IBM card data file form for study by other contractors and services.

ture are carefully controlled, have been adopted. Fabrication workers and production test personnel wear face masks and special lint-free clothing in many critical areas.

Also unique in the project is that each unit delivered by IRC has its personal history attached (Fig. 4). Complete records on all raw materials and process characteristics are maintained and individual IBM cards, recording detailed test results for each resistor are made available. Because of this complete documentation, the IRC project is expected to determine new specifications as to what factors are important in the making of a good resistor—knowledge which will benefit the entire industry and advance the reliability of microcircuits, in which resistive elements are deposited as an integral part of a sophisticated functional component.

Characteristics of the IRC "High Reliability" Resistor

The resistors are being produced in the 25, 50 and 100 ppm/° C temperature coefficient classes. They meet all Air Force requirements with characteristic performance well within the limits prescribed in that specification, including those in the following table.

Quality Test Parameter	Test Limits Within
Resistance Tolerance	1% of nominal
Temperature Cycling	ΔR not to exceed ±0.2% +0.05 ohm
Los Temperature Operation	ΔR not over ±0.2% +0.05 cfm
Short Time Overload	ΔR not over 0.2% +0.05 ohm
Terminal Strength	ΔR not over 0.2% +0.05 ohm
Dielectric Voltage Test	ΔR not over 0.2% +0.05 ohm
Insulation Resistance	not less than 10,000 megohms
Effect of Soldering	ΔR not over 0.1% +0.05 ohm
Moisture Resistance	ΔR (initial to final) not over ±0.5% — 0.05 ohm with insulation resistance 100 megohms min.
Load Life	ΔR (between initial and any succeeding measurement) not over ±0.5% +0.05 ohm
Acceleration	ΔR not over ±0.2% +0.05 ohm
High Frequency Vibration	ΔR not over ±0.2% +0.05 ohm
High Temperature Exposure	ΔR not over 0.2% +0.05 ohm

FOR MORE INFORMATION CIRCLE 131 ON READER-SERVICE CARD

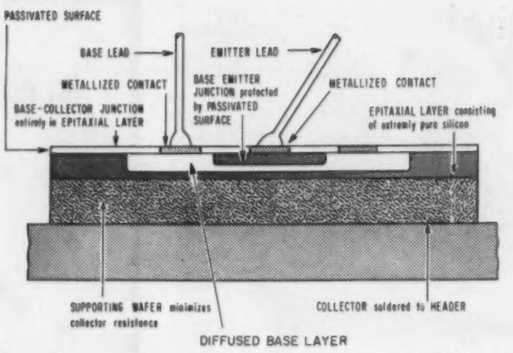


FIG. 1. CROSSECTION representation of Epitaxial Planar Transistor.

What is Epitaxial?

"*EPITAXIAL*" is the latest catchword to enter the vocabulary of the semiconductor industry. Considerable confusion has been generated concerning the meaning of the word and the significance of the development. The advantages introduced by this new technology have not been clearly stated, and its relationship to existing transistor structures has been particularly obscure.

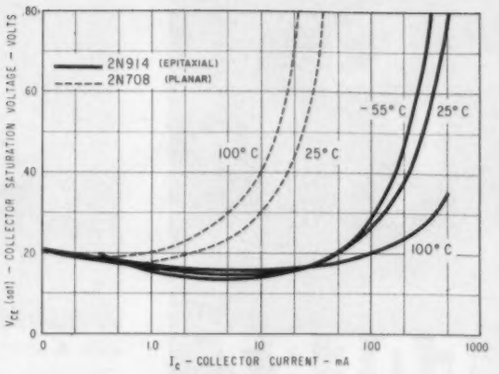
One gets little help from the dictionary in clearing up the confusion. One authority[1] defines the word *epitaxy* as follows: "Oriented intergrowth between two solid phases. The surface of one crystal provides, through its lattice structure, preferred positions for the deposition of the second crystal."

Unfortunately, an epitaxial transistor is made completely without the oriented intergrowth of two solid phases. Instead for epitaxial transistors a step is included wherein a thin layer of semiconductor material is grown on a relatively thick slab of the same material by means of a chemical reaction. While technically this is not epitaxy, since the same solid phase is involved, the term has been well established with respect to the resulting structure.

[1] International Dictionary of Physics and Electronics (D. Van Nostrand Co., Inc., 1956).

The Author

DR. GORDON E. MOORE, **Director** of Research & Development, Fairchild Semiconductor Corporation, has been with that firm since its formation in 1957. Previously with the research staff of Shockley Semiconductor Laboratory and in basic molecular research with the Applied Physics Laboratory, John Hopkins University; he holds a PhD degree in chemistry and physics from the California Institute of Technology.



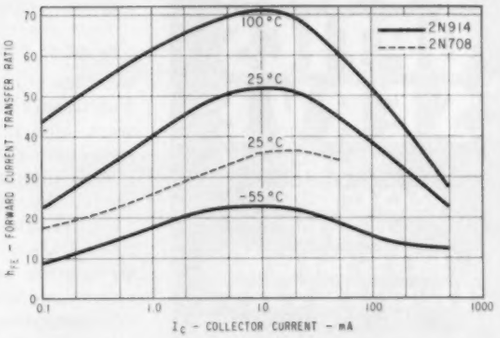


FIG. 2. V_{ce}(sat) and H_{fe} vs I_c characteristics of Epitaxial Planar Transistor 2N914 are compared with corresponding curves for the standard Planar 2N708.

Improvement In Planar Transistor Characteristics Though Epitaxial Techniques (25°C unless otherwise noted)

	V (Sat) at[ce] I_{cc} 10 ma	V (Sat) at[ce] I_{cc} 200 ma	Charge Storage Time Constant τ_s
2N914 Planar Epitaxial	0.25v. (−55° to 125°C)	0.4v.	20 n-sec.
2N708 Standard Planar	0.4v.	no operation	25 n-sec.

The slab of semiconductor with the added "epitaxial" layer is then processed by exactly the same diffusion processes as are used in making conventional mesa or planar transistors to yield epitaxial transistors. The fact that only the step of deposition of the initial layer is added to the standard process has resulted in these devices entering production much more rapidly than has been the rule with other developments in this field. Depending upon the particular process employed, the resulting devices are more completely described as mesa epitaxial or planar epitaxial transistors. The two adjectives describe completely independent attributes. Epitaxial does not supplant mesa or planar, it supplements them. For example, the performance advantages contributed by the epitaxial process are added to the planar advantages of highest reliability, low leakage currents, low noise and low current operation in the planar epitaxial structure.

tributed by the "extra" material in a conventional transistor. In a conventional diffused structure, either mesa or planar, the active portions of the transistor are contained in a layer no more than a few ten-thousandths of an inch thick on the top surface. The actual piece of semiconductor material is usually several thousandths of an inch thick, since handling of structures much thinner is very difficult. When this entire thickness of several thousandths of an inch is all cut from one large crystal, it has, of necessity, about the same purity and electrical conductivity throughout. This purity is adjusted to that necessary to yield the correct characteristics in the very thin, diffused structure to be made on the top surface. The "excess" material in this case has relatively little impurity and hence adds an appreciable resistance in the collector of the transistor. It also stores electrical charges to slow down switching speeds.

In the epitaxial case (Fig. 1), the "excess" material only is cut from the original crystal. It is doped to have very high electrical conductivity. This slab is then placed in a vessel at high temperature and subjected to an atmosphere of hydrogen and a gaseous compound, usually a chloride, of the semiconductor in question. The correct amount of dope is added to the gas stream. The hydrogen reduces the compound, depositing lightly-doped semi-conductor material (of the same conductivity type as the substrate, either N or P). This layer is grown until it is just thick enough for the desired transistor structure. In this case, the extra material does not contribute measureable resistance. Because it is so impure, charge storage is also greatly reduced. These effects result in considerable improvement in the electrical characteristics. Because of the lower resistance more current can be passed through the same size device and low charge-storage times and low saturation resistances are obtained.

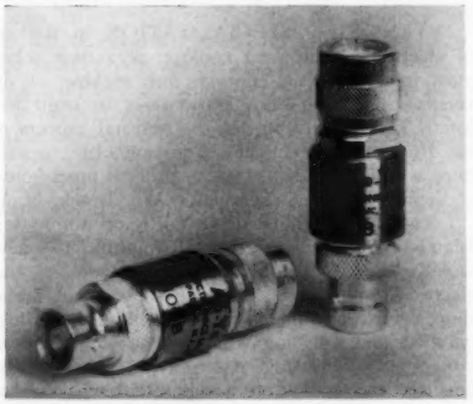
The significance of the improvements can best be pointed out by comparing an epitaxial device with its standard transistor counterpart. At Fairchild Semiconductor, for instance, the planar epitaxial 2N914 transistor is essentially the firm's epitaxial version of its standard planar 2N708 transistor. While most of the electrical characteristics of the two devices are identical, the advantage of the epitaxial device becomes apparent when the collector saturation voltages and temperature ranges of the devices are compared. The 2N708 planar has a V_{CE} (sat) of 0.4 volts maximum at 25° C with a collector current of 10 ma, base current 1.0 ma. Under the same conditions of collector and base current, but over a wide temperature range of −55° C to + 125° C, the planar epitaxial 2N914 has a V_{CE} (sat) of only 0.25 volts maximum. In addition to this, the planar epitaxial device shows a typical collector saturation of 0.4 volts when operated at a collector current of 200 ma. The standard 2N708 device will not operate at that current. The charge storage time constant τ_s is also reduced 20% in the 2N914 from 25 to 20 ns. At some penalty in V_{CE} (sat) the charge storage time constant can be reduced still further on the epitaxial unit.

Thus, the advantages of the epitaxial structure are those of decreased collector saturation voltage, especially at high current levels, decreased charge storage, and decreased temperature dependence of collector saturation voltage. When these advantages are coupled with the low leakage, high current gain over a broad current range and inherent reliability of the planar structure in the planar epitaxial transistor, the resultant device is extremely reliable and useful over a broad range of current levels and environments.

FOR MORE INFORMATION CIRCLE 132 ON READER-SERVICE CARD

Small Coaxial Attenuators

A new series of small coaxial attenuators meeting MIL-Specs, developed for decreasing standing wave ratio of coaxial systems, are also proving very suitable for decreasing signal amplitude for frequencies up to 5000 megacycles. The resistive elements, arranged in a



"T" network, are specially made with carbon film to maintain constant attenuation from dc up to 5 kmc. They are a development of the Ad-Yu Electronics Lab., Inc., 249-259 Terhune Ave., Passiac, N. Y.

Specifications of the new attenuators include:

Maximum VSWR is 1.02 to 1.1 from dc to 1 kmc; 1.1 to 1.2 from 1 to 3 kmc; and 1.2 to 1.3 from 3 to 5 kmc. Maximum power and dissipation is 1 watt continuous or 1 kilowatt instantaneous peak signal. Input and output impedance are both 50 ohms and the temperature coefficient is less than 0.0005 db/°C. In the frequency range from dc to 3 kmc, accuracy of attenuators below 3 db is ±0.1 db; from 3 to 20 db, ±0.2 db; and for units above 20 db, ±0.5 db. Accuracy limits for the same units in the range from 3 to 5 kmc are slightly higher.

Standard coaxial attenuators are stocked at integral db values from 1 to 6, plus 8, 10, 15 and 20 db. Other values from 0.1 db to 60 db in steps of 0.1 db are available on request. Length of each coaxial attenuator including connectors, is only 2" ± 1/64".

Although connectors for standard units are furnished in Type C female on one end and Type C male on the other; Types N and BNC, male or female on either or both ends, can be supplied on request.

FOR MORE INFORMATION CIRCLE 133 ON READER-SERVICE CARD

New Muffin Fan is Product of New Factory

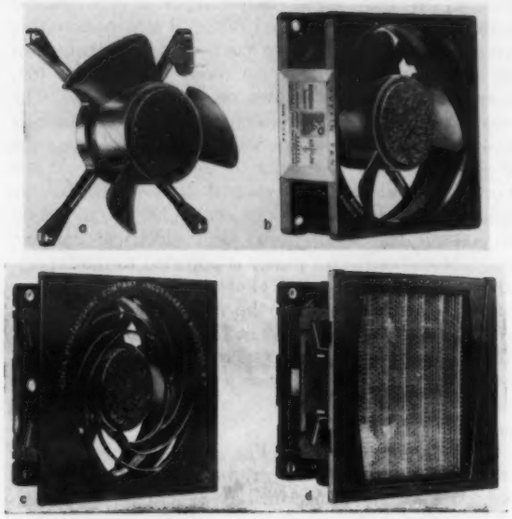


FIG. 1. GOLD SEAL Muffin Fan is available in four standard versions: (a) Skeleton, (b) Venturi, (c) Grille and (d) Filter configurations. The complete cooling-filter package (d) extends only 2 13/64" behind the front surface of the panel in which the fan is mounted.

INTENSIFIED SPECIALIZATION in the art of electronic equipment cooling, at a time when most manufacturing concerns are seeking to diversify their base of operations—is in itself unusual. This is only one of the unusual aspects of the Rotron Manufacturing Company, Inc., operations which were displayed in a recent open house at their new plant just outside Woodstock, N. Y.

Located a two-hour drive north of Manhattan Island in the pine-clad Catskill foothills, the new facilities include complete acoustic, chemical and electrical laboratories, machine shop, sheet metal shop, centrifugal casting, plastic molding, welding, painting and finishing winding and impugnation, inspection and testing. Assembly of many of the fans are carried out at a separate facility about four miles distant.

The Rotron Manufacturing Company began about 14 years ago in the application of known aerodynamic principles which were then not being applied in the cooling of electronic equipment. The new Gold Seal Muffin Fan, put on display 1 June, is the logical development of these ideas. This version of the 100 cfm Rotron Muffin fan, first announced two years ago, is only 1-1/2" deep and 4-11/16" square, has retained the basic wound "internal" stator with its fan and "external" rotor cast in one integral unit.

The "Gold Seal" version provides an improved bearing system for longer life, extra high impact-strength plastic case and very quiet aerodynamic grille design. It is available in four versions (Fig. 1) as (1) a skeleton fan for mounting in the customer's enclosure, (2) as a Venturi fan for mounting in a round or square equipment panel, (3) as a grille fan or (4) as a matched fan and filter package. Performance of the Gold Seal Muffin fan in its various configurations is shown by the Volume vs Pressure graphs in Fig. 2. Quiet operation of the new design is shown by the sound spectrum (Fig. 3) which falls below the ambient noise level average for engineering drafting rooms.

All phases of the manufacturing operation are under the development and engineering control of the Rotron plant, including the formulation of plastics and other materials purchased from other suppliers. Complete testing and inspection facilities exist for both acceptance testing, quality control of production and for life and Mil-Spec testing of finished products.

Advanced production methods used in manufacture of the Gold Seal fan include insulation of the stator and rotor laminated cores with baked epoxy insulations. Epoxy encapsulation as well as impregnation techniques are being used in stator windings.

A high order of morale was evident in the attitude of the craftsmen as well as that of the engi-

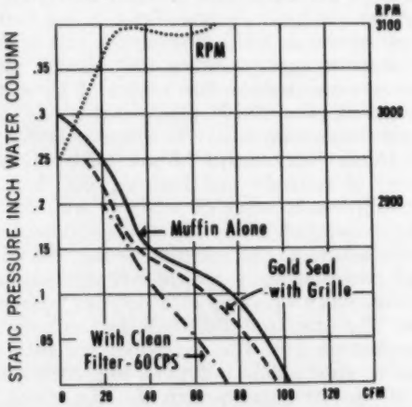


FIG. 2. VOLUME vs Pressure Curves for the Gold Seal Muffin Fan configurations (b) to (d) as shown in Fig. 1.

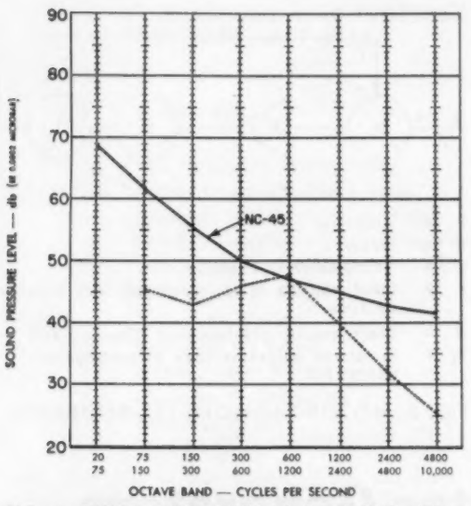


FIG. 3. QUIET OPERATION of the Gold Seal Fan is shown in sound level spectrum (dotted line) taken only 3 ft from the fan. Solid line shows average ambient noise spectrum for engineering-drafting room spaces.

neering staff. One young molder, demonstrating the method of centrifugal casting by which the Muffin-fan blades and armature-winding assembly are cast as a single unit, remarked, "Our shop is the only place in the U. S. that can turn out that type of casting within .003" concentricity." Then, "If that sounds like I'm bragging, I am!" he proudly added.

Rotron's engineering and test facilities include electric power sources for all frequencies from 50 to 2000 cps, including a square-ware generator capable of supplying any desired frequency.

Life-testing and Mil-Spec testing of Rotron blowers and fans is a regular order of business in the laboratory, which is equipped with heat, cold, humidity and altitude test chambers (Fig. 4). One germanium-diode blower, built to Western Electric Specification, is undergoing a 40-year ambient temperature life test. Operating continuously since December 1957, it is lubricated while in operation

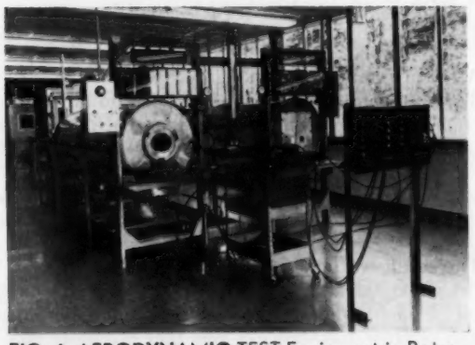


FIG. 4. AERODYNAMIC TEST Equipment in Rotron Laboratory defines air flow characteristics of Rotron products under actual altitude and load impedance conditions.

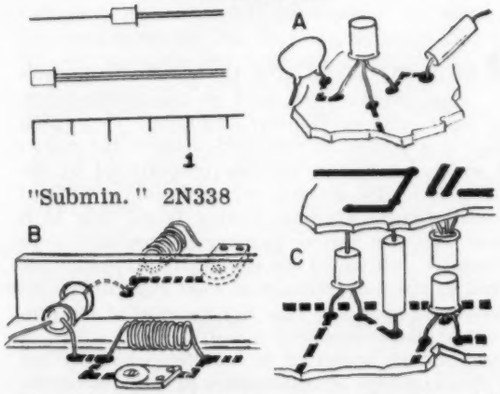
once a year. Evidently Western Electric has faith that the test will turn out satisfactorily, as they have accepted delivery of fans without waiting for conclusion of the test!

Products of the Rotron plant have totalled over 620 versions to date. These range from 2" diameter fans rated at .005 hp to their "giant" 4 hp 400 cps blowers. A sample motor of each separate variation is maintained in the Rotron Fan-blower museum. Many of these fans were engineered to meet specific customer demands. The samples are invaluable in meeting new requests for non-standard cooling devices in that they are readily available for test in the new application, and can be quickly duplicated from engineering drawings on file.

Founder and president of the Rotron Manufacturing Co., Mr. J. Constant van Rijn (pronounced Rine), mentioned the steady growth of Rotron over the past 14 years as due to a concentration on the special problem of electronic equipment cooling. He stated that with increasing miniaturization and component densities, the problem of heat transfer grows more acute, while the space available to accommodate fans and blowers becomes even smaller. Mr. van Rijn said that Rotron has had the urge to do things the right way regardless of immediate profit, and that the welfare of the people who work in the plant has been a potent factor in the design of the new plant. His intention is to create a plant which will, by its architectural beauty, complement the beauty of its natural setting.

FOR MORE INFORMATION CIRCLE 134 ON READER-SERVICE CARD

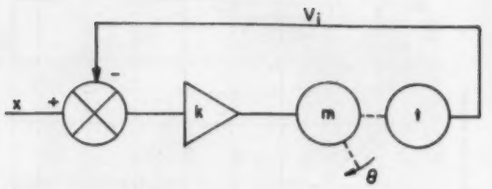
Single-and Double-Ended Transistors



New Raytheon Subminiature transistors offer: (A) Familiarity in the single-ended package for high density in standard board assembly—dip soldering—heat sinking; (B) unusual versatility with the double-ended package for feed-through construction—nonplanar double board mounting—open frame welded assembly; and (C) greater adaptability using both single and double-ended devices to optimize mechanical assembly.—(*From* 30-*page "Designers Handbook, HF Type* 2N338 *Silicon Transistor", Raytheon Company, Semiconductor Div., 150 California St., Newton, Mass.*)

FOR THIS LITERATURE CIRCLE 135 ON READER-SERVICE CARD

FIG. 1. THERMISTOR-COMPENSATED motor-tachometer-generator (Size 18). Frequency sensitivity: 0.015%/cycle; Voltage sensitivity: 0.008%/volt; Temperature error +25±50°C: ±0.05%.



k = Amplifier
m = Motor
t = Tachometer – generator
x = Input voltage to be integrated with respect to time
θ = Shaft angular displacement (Equals ∫ x dt)
V_i = In-phase output voltage of tachometer-generator

FIG. 2. MOTOR-TACHOMETER-GENERATOR used in an integrating circuit.

Precision Tachometer-Generators

with Thermistor Compensation

A series of rapid changes has characterized tachometer-generator development. This discussion presents a chronological survey of developments which have become the standards of precision in the industry today. Trends, future needs, and expected developments also are discussed.

CHARLES PEPE
Kearfott Division,
General Precision, Inc.

PRIOR TO World War II, two-phase squirrel-cage motors were used as tachometer-generators for stability applications (damping). Energizing voltage was applied to the fixed-phase of the motor, and an output voltage roughly proportional to the speed at which the unit was driven was obtained from the control-phase winding. During World War II it became apparent that ac tachometer-generators were particularly well suited for computation applications as well as damping because of their ruggedness, reliability, and accuracy. This was the start of the precision tachometer-generator industry.

Evolution in design of tachometer-generators led to a drag-cup type of construction in order to obtain accurate computations with ac signals of a particular phase. There is no difference in the basic theory of operation between a drag-cup tachometer-generator and a two-phase squirrel-cage motor used as a tachometer-generator. In both cases, output voltage is developed as follows: At zero speed the energizing flux, because of the positioning of the input and output coils, yields no voltage in the output winding (ideally). An electrically conducting non-magnetic cup, when rotated in this field, produces a flux which is (1) proportional to speed and (2) perpendicular to the energizing flux. This flux is now in such a direction that it induces voltage in the output winding. The faster the cup is driven, the greater the flux produced and the larger the magnitude of the induced output voltage. The frequency of the output voltage is the same as the frequency of the energizing flux. Advantages of this type of generator design over the squirrel-cage construction include: (1) Small phase shift between the energizing voltage and the output voltage and (2) lower residual voltages.

Tachometer-generators used for computing applications (such as integrating, differentiating, and squaring) require higher precision than those used for loop stability (damping). Precision is required in most computation applications because any error in the tachometer-generator output contributes a direct error in the computations involved.

Terminology

A list of symbols and definitions is shown in Table 1. This list represents the first agreement to be reached by representatives of the tachometer-generator industry, both users and manufacturers. It was agreed on by a Standardization Panel sponsored by the SAE, whose objective was the formation of an *Aeronautical Recommended Practice for Motor Tachometer-Generators.*

The result is designated ARP 667.

Let us now consider a simple integration operation using a tachometer-generator, discussing the main causes of error and showing how they are overcome.

The Integration Operation

A typical computation application of the precision

TABLE 1—DEFINITIONS (SAE PROPOSED STANDARD—ARP 667)

Symbol	Symbol at Calibration Speed	Explanation*
V_{en}		Energized Voltage
N	N_c	Speed
V_o	V_{co}	RMS Fundamental Output Voltage
V_i	V_{ic}	In-Phase Fundamental Output Voltage
V_q	V_{qc}	Quadrature Fundamental Output Voltage
V_{ss}	V_{ssc}	RMS Fundamental Speed-Sensitive Output Voltage
V_{ssi}	V_{ssic}	In-Phase Speed-Sensitive Output Voltage
$V_{nnl\ h}$		RMS Harmonic Voltage
$V_{axis\ i}$		In-Phase Axis Voltage
$V_{axis\ q}$		Quadrature Axis Voltage
$V_{pos\ i}$		In-Phase Position Voltage
$V_{pos\ q}$		Quadrature Position Voltage
TR		Transformation Ratio

motor tachometer-generator is an integration operation (Fig. 2). In this circuit, if the amplifier gain is high enough, the voltage from the tachometer-generator (V_t) will be equal to the input voltage x:

$$V_t = x$$
$$V_t = d\theta/dt \text{ (tachometer output)}$$
$$x = d\theta/dt$$
$$xdt = d\theta$$
$$\int xdt = \int d\theta$$
$$\int xdt = \theta.$$

Thus θ, the shaft angle displacement of the tachometer-generator, is equal to the integral of the input voltage x with respect to time.

With this application as a reference, an error analysis was made with a BuOrd Mk 12 (developed in 1948) as the motor-tachometer-generator. Because the integrator shown was phased so as to be in-phase-sensitive only, the analysis included only in-phase errors. (Quadrature and harmonic voltages can be kept to a minimum by calibration and design).

Analysis of Tachometer—Generator Errors

Assuming a constant load on the output, variable external conditions affecting accuracy of the tachometer-generator output can be graded in the order of severity introduced errors as follows:

1. Ambient Temperature
2. Excitation Frequency
3. Speed (nonlinearity)
4. Excitation Voltage

For this analysis the ranges within which the unit must operate satisfactorily are:

Ambient temperature: 25 ± 50°C

Energizing frequency: 400 ± 20 cps

Energizing voltage: 115 ± 10 volts

Speed range: 0 to 3600 rpm

Standard operating conditions are: 25°C ambient, 115v, 400 cps excitation, 0 to 3600 rpm speed range, Nc = 3000 rpm, and In-Phase Speed-Sensitive output voltage (V_{ssi}) = 10 volts at 3600 rpm. As the initial value of the in-phase axis voltage ($V_{axis\ i}$) can be bucked out with an equal and opposite voltage,

* For amplified explanations see pp. 32-34 inc.

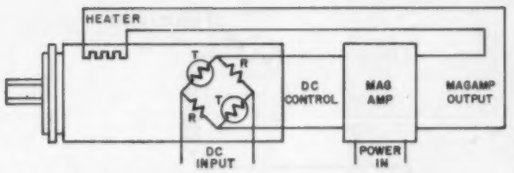


FIG. 3. THERMAL SERVO LOOP utilizes a magamp to provide continuous temperature control. T= Thermistors; R=Low-temperature-coefficient, wire wound resistors; Magamp power gain=Approximately 250,000.

we can assume at standard conditions $V_{axis\ i} = 0$.

The resulting errors from the varying conditions are shown in Table 2. The temperature error was large.

To correct this weakness, a thermostatic temperature control was developed (in 1948) to keep the temperature of the unit constant although the ambient temperature was varying. The temperature-caused error of this tachometer-generator (Mk 2) was reduced by a factor of approximately ten. The percentage error due to changing $V_{axis\ i}$ became insignificant. The temperature-caused error was reduced by another factor of approximately ten by the development of a thermal servo loop (in 1954) which utilized a magamp and yielded continuous temperature control (Fig. 3).

At this point the temperature-caused errors had been reduced to the value of the errors caused by the other conditions. The next stage in development of precision tachometer-generators was to reduce the other errors (as well as to reduce temperature-caused error still further).

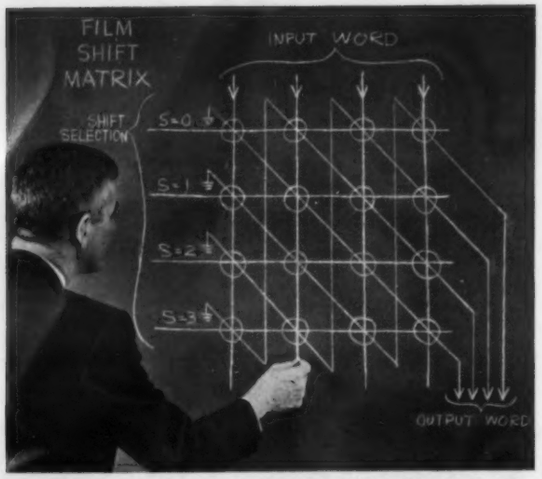
Basic temperature sensitivity of the tachometer-generator is caused mainly by changes in energizing-winding resistance and drag-cup resistance. With improved magnetic and mechanical design, and use of lower-temperature-sensitivity materials for drag cups, improvement has been made in all four error areas. To show the magnitude of the improvement, Table 3 was prepared using a currently available tachometer-generator (Kearfott #U720-001). In order to give a true comparison, temperature-caused error of the basic tachometer is shown without temperature control or compensation because the errors shown in Table 2 also came from a basic tachometer-generator.

Thermistor Compensation

With the emergence of tachometer-generators with low sensitivity to temperature changes, there arose the possibility of reducing temperature-caused errors by thermistor compensation. That is, the thermistor's negative temperature characteristic could be used to neutralize the temperature error of the tachometer-generator. One such circuit is shown in Fig. 4.

The reduction of sensitivity to temperature variations has been so great that over an ambient range of 100°C (25 ± 50°C), a thermistor compensated motor-tachometer-generator such as Kearfott's V860 (shown in Figure 1) yields errors of less than 0.05%.

The less-temperature-sensitive material used now on drag cups is three times more dense than materials



This logic array has been developed in the Remington Rand Univac Mathematics and Logic Research Department. In simplified form, each circle represents a film element that AND's the bits from the horizontal and vertical lines to produce an output on the diagonal line. The input word is therefore left-circular shifted S places in passing to the output. Such matrixes can produce arbitrary right or left shifts, either circular or open-ended, in a single clock period for full length computer words. Film logic arrays open a new field of high speed, high density logic devices.

No where in the computer industry will qualified applicants find greater opportunity for both personal and professional reward than they will today at Univac. Highly significant positions involving work such as that outlined above are now available. You are invited to investigate them immediately.

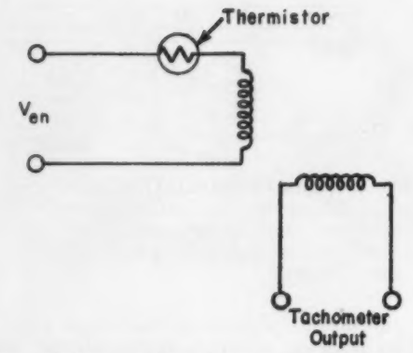


FIG. 4. **THERMISTOR** whose temperature characteristic neutralizes temperature error of tachometer-generator improves basic temperature error by a factor of approximately ten.

TABLE 2—ERRORS CAUSED BY VARYING OPERATING CONDITIONS ON EARLY TACHOMETER.

Condition	Parameters Producing Error	Magnitude** of Error @ 3600 rpm	Error in % of V_{ssi} @ 3600 rpm	Magnitude of Error @ 1800 rpm	Error in % of V_{ssi} @ 1800 rpm
25 ±50°C	V_{ssi}	±1.25 v	±12.50	±0.63 v	±12.50
25 ±50°C	*$V_{axis\ i}$	±10 mv	± 0.10	±10 mv	± 0.20
400 ±20 cps	V_{ssi}	±60 mv	± 0.60	±30 mv	± 0.60
0-3600 rpm	V_{ssi}	±20 mv	± 0.20	±10 mv	± 0.20
115 ±10 v	V_{ssi}	±20 mv	± 0.20	±10 mv	± 0.20
	Total Possible Error =		±13.60		= ±13.70

*It should be noted that the magnitude of $V_{axis\ i}$ change remains the same at any speed. Therefore, at 1800 rpm, for example, the % error doubles.

**See Amplified Definitions (below) for equations governing these errors.

used previously. Hence inertia has increased by a factor of approximately three. Future development is aimed at (1) providing a low-temperature-sensitivity material with low density, (2) other methods of compensating, and (3) investigating the possibility of changing the basic design philosophy of tachometer-generators so as to eventually obtain a well-designed precision unit which is insensitive to varying conditions.

Amplified Definitions (ARP667)

In-Phase Output Voltage (Vi)

That portion of the RMS fundamental output voltage (V_o) which is in time phase (or 180° out of phase) with the fundamental energizing voltage (V_{en}). At any speed N, the in-phase output voltage is made up of two parts, the in-phase, speed-sensitive output voltage (V_{ssi}) and the in-phase axis voltage ($V_{axis\ i}$).

$$V_i = V_{ssi} + V_{axis\ i}$$

In-phase output voltages are positive if in-phase and negative if 180° out of phase.

Quadrature Output Voltage (V_q)

That portion of the RMS fundamental output voltage (V_o) which is 90° or 270° out of time phase with

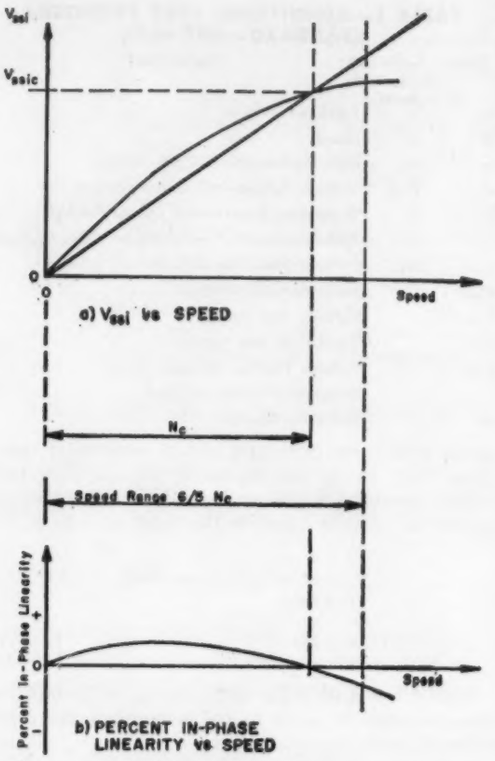


FIG. 5. **IN-PHASE SPEED-SENSITIVE** output (V_{SSI}) and In-Phase Linearity vs Speed.

TABLE 3—ERRORS CAUSED BY VARYING OPERATING CONDITIONS ON A CURRENT MODEL (WITHOUT COMPENSATION)

Condition	Parameters Producing Error	Magnitude in mv of Error @ 3600 rpm	Error in % of V_{ssi} @ 3600 rpm
25 ±50°C	V_{ssi}	±27	±0.38*
25 ±50°C	$V_{axis\ i}$	±1.5	±0.02
400 ±20 cps	V_{ssi}	±12	±0.16
0-3600 rpm	V_{ssi}	±2	±0.02
115 ±10 v	V_{ssi}	±5	±0.07
	Total Possible Error =		±0.65

*Tachometer with no temperature control or compensation. This error can be sharply reduced if either is applied.

the energizing voltage (V_{en}). At any speed N, the quadrature output voltage is made of two parts, the quadrature speed-sensitive output voltage (V_{ssq}) and the quadrature axis voltage ($V_{axis\ q}$).

$$V_q = V_{ssq} + V_{axis\ q}$$

Quadrature output voltages are positive if 90° and negative if 270°.

In-Phase Speed Sensitive Output Voltage (V_{ssi})

(a) That portion of the RMS fundamental speed-sensitive output voltage (V_{ss}) that is in time phase or 180° out of time phase with the energizing voltage (V_{en}). It is equal to ½ the difference of the measured in-phase fundamental output voltage (V_i) ccw and cw

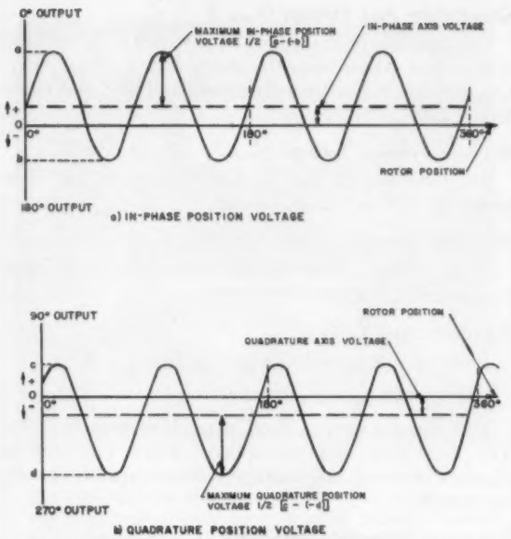


FIG. 6. IN-PHASE and quadrature zero-speed output voltage vs. stationary rotor position.

at the same rotational speed N (see Fig. 5).

$$V_{ssi} = \tfrac{1}{2}\,(V_{i\ ccw} - V_{i\ cw})$$

(b) In-Phase Speed-Sensitive Voltage (V_{ssic}) designates the in-phase speed-sensitive output voltage for the special case at calibration speed N_c.

$$V_{ssic} = \tfrac{1}{2}\,V_{ic\ ccw} - V_{ic\ cw})$$

In-Phase Linearity Error

The deviation of the in-phase speed-sensitive output (V_{ssi}) from an arbitrary straight line is such that the maximum positive deviation and the maximum negative deviation are approximately equal. This arbitrary straight line is a function of speed. It is expressed as a percent of the in-phase ss output voltage at the maximum speed. The following formula applies:

$$\%\ \text{in-phase linearity error} = \frac{V_{ssi} - \frac{N_c}{N}\,(V_{ssic}) \times (100)}{6/5\ (V_{ssic})}$$

where V_{ssi} is taken at speed N (See Fig. 5).

The value of calibration speed N_c to be used to calculate percent linearity error turns out to be approximately 5/6 of the maximum speed of a specified speed range. The following combination of N_c and speed ranges are to be considered standard.

Speed Range	N_c
0-1800	1500
0-3600	3000
0-4300	3600

In-Phase Axis Voltage ($V_{axis\ i}$)

That portion of the axis voltage which is in phase or 180° out of phase with the energizing voltage (V_{en}). In-phase axis voltages are positive if in-phase, and negative if 180° out of phase (Fig. 6).

Quadrature Axis Voltage ($V_{axis\ q}$)

That portion of the axis voltage which is 90° or 270° out of time phase with the energizing voltage (V_{en}). Quadrature axis voltages are positive if 90°, and negative if 270° (Fig. 6).

In-Phase Position Voltage ($V_{pos\ i}$)

That portion of the position voltage which is in phase or 180° out of phase with V_{en} (Fig. 6).

Harmonic Voltages

That portion of the output voltage of other than fundamental frequency.

Transformation Ratio

Ratio of output voltage to energizing voltage.

Energizing Voltage Sensitivity

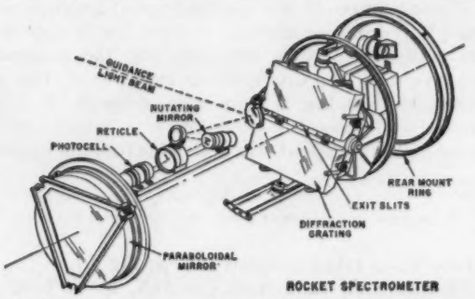
The changes in measured, rated condition in-phase TR, phase shift, and zero speed voltages due only to changes in energizing voltage within a specified voltage range.

Energizing Frequency Sensitivity

The changes in measured, rated condition in-phase, speed-sensitive output voltages, phase shift and zero speed voltages due to changes in ambient temperature within a specified temperature range.

Rocket-Borne Spectrometer

ULTRAVIOLET ENERGY emitted by stars is to be studied by a spectrometer borne aloft in an Aerobee-Hi rocket. This type of observation cannot be made from the earth's surface because of the opacity of the atmosphere. The project is the Princeton's Observatory's Rocket



ROCKET SPECTROMETER

Probe Study Program under the direction of Dr Lyman Spitzer, Jr. and supported by NASA.

In operation, the spectrometer (see Figure) will scan the ultraviolet regions of the spectrum during a period lasting less than five minutes. The instrument will record the ultraviolet light emitted by the stars when the rocket is some 62 to 143 miles above the eath. Detailed information will be telemetered back to earth immediately as the entire spacecraft will be destroyed on reentering the earth's atmosphere.

The spectrometer design emphasizes compactness, light weight and low power requirements. It has been designed by the Perkin-Elmer Corporation of Norwalk, Conn., to fit into a package only 30" long, 14" in diameter. The fine guidance system is capable of holding the instrument "on target" within ±6 seconds of arc.

MICROFILM TV system exhibit at WESCON. Remote Monitor station is shown at left with control stick in the foreground. Hi-REZ monitor shows enlarged portion of engineering drawing. Center microfilm televiser, normally at central file location, rests on table.

Viewer-Controlled CC-TV

A new microfilm readout device developed by GPL Div., General Precision, Inc., Pleasantville, N. Y., when tied to closed-circuit television permits one or more users to simultaneously examine microfilm with a wide range of magnification—even if separated from the file and from each other by several miles.

For access to microfilmed data in a remote location, a user calls a central file. In response to his request, the microfile librarian inserts a microfilm aperture card in the televiser and the data is transmitted to his monitor. The viewer using a single "joy-stick" control, can move any part of the picture to the center screen position and then change its magnification continuously through the entire range up to a 300 time enlargement without loss of focus.

A number of viewers in different locations may view the same drawing, as might be required in a telephone conference situation. However, only one remote station is given control of positioning and magnification. This feature would also make available graphic aids from a centralized library to classroom teachers, greatly simplifying the administration of graphic aids in public or military schools.

The type of line required for transmission of the GPL HI-REZ (High Resolution) 1000 line TV system signals is coaxial or microwave line having a 20 mc bandwidth. With standard 525 line TV, a bandwidth of either 5 or 8 mc could be used.

Through the use of auxiliary equipment, aperture film cards can be automatically inserted in the Microfilm Televiser. The equipment is also compatable with automatic search, retrieval and inserting equipment which would permit a minimum of attention on the part of the central film librarian.

The Microfilm Televiser will be on display in the GPL Division booth, No. 3309-3321, at the WESCON 61 Show.

FOR MORE INFORMATION CIRCLE 138 ON READER-SERVICE CARD

CIRCLE 48 ON READER-SERVICE CARD ⟶

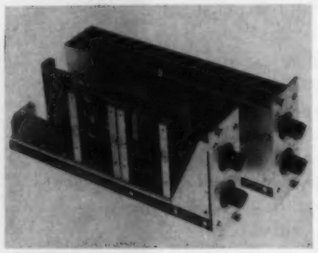
WESCON Product Previews

MICROWAVE ANTENNAS

Expanded lines of Antennas, antenna feeds and accessories, including the Taco rigid transmission line using expansion bullets to compensate for long-run thermal expansion and contraction, will be displayed at WESCON Booth, 8350.—*Technical Appliance Corporation, Sherburne, N. Y.*

CIRCLE 139 ON READER-SERVICE CARD

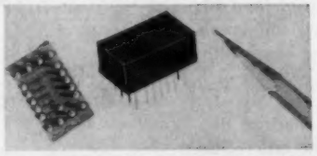
TRANSISTORIZED INSTRUMENTS



New 1800 Series instruments use solid-state sub-modules including operational amplifiers to provide a variety of gain ranges, gain steps, frequency responses and outputs.—*Burr-Brown Research Corp., Box 6444, Tucson, Ariz.*

CIRCLE 140 ON READER-SERVICE CARD

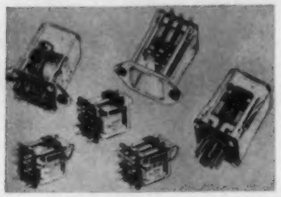
DATA CONVERTER MODULES



New BIPCO® micro-electronic modules convert binary coded decimal information to decimal form. Operate with Burroughs TRIXIE® modules to drive NIXIE® indicator tubes directly from low-level binary coded inputs.—*Burroughs Corporation, Electronic Components Div., P. O. Box 1226, Plainfield, N. J.*

CIRCLE 141 ON READER-SERVICE CARD

PLASTIC CASE RELAYS



New Model GR general purpose relays are adaptable for below-chassis, above-chassis and plug-in connections with solder-push-on terminals grouped on single barrier panel. AC and DC types with coil voltages to 440 vac or 230 vdc, configurations to 3-pole double-throw, and contact ratings to 5 amp 115 vac or 32 vdc are available in enclosed or unenclosed types.—*Ohmite Mfg. Co., 3672 Howard St., Skokie, Ill.*

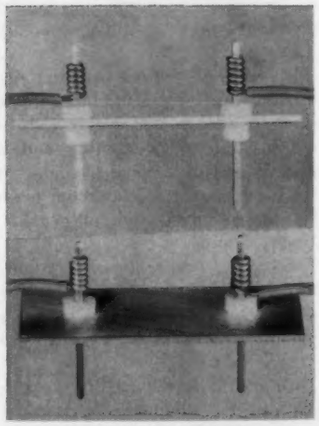
CIRCLE 142 ON READER-SERVICE CARD

STRIPED MARKERS

Self-sticking Color Stripe Markers for coding resistors, etc. replace painted stripes—are faster to apply than paint, either manually or by automatic machine. Samples on request.—*W. H. Brady Co., Dept. 138, 727 W. Glendale Ave., Milwaukee 9, Wisc.*

CIRCLE 143 ON READER-SERVICE CARD

WIRE WRAP CONNECTOR



New "Press-Fit" Feedthru Terminal Part No. FT-WJ-100 designed for Wire Wrap connection techniques is rectangular in cross-section. Presses into secure seating in punched chassis. Stud extends .460" above chassis, .459" below.—*Sealectro Corporation, 610 Fayette Ave., Mamaroneck, N. Y.*

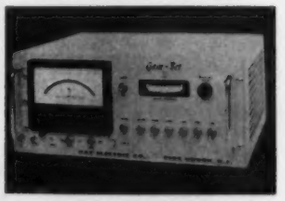
CIRCLE 144 ON READER-SERVICE CARD

DC AMPLIFIER

New Coldstream model 1T300 dc amplifier utilizes a second harmonic modulator operating at an excitation frequency of 2000 cps amplified by a two-stage ac amplifier whose output feeds a phase-sensitive demodulator. This bi-directional output is fed in turn to a balanced push-pull cathode follower. A portion of the output is fed back to the modulator for gain and temperature stabilization. Gain steps of 10, 100, 1000 and 3500 are standards.—*Coldstream Engineering Co., Box 1893, Tulsa, Okla.*

CIRCLE 145 ON READER-SERVICE CARD

GAIN/NOISE METER



New Model 625-A Gain Set, designed to measure gain, loss, noise figure and other microwave characteristics incorporates crystal mixer 20-step attenuator, IF amplifier and detector, AGC amplifier and output meter.—*Kay Electric Co., Maple Ave., Pine Brook, N. J.*

CIRCLE 146 ON READER-SERVICE CARD

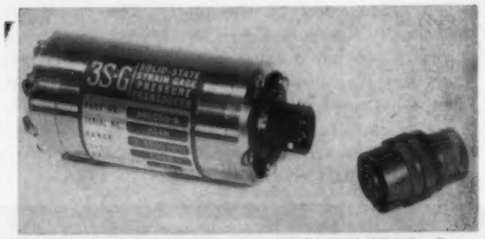
MIL INDUCTORS

New microminiature inductors in the Dura-Clad® package meeting environmental requirements of MIL-C-15305A, Grade 1, Class B (125°C) are available in the 03-series (center) 10μh to 100 mh; and in the 04-series, lmh to 1 henry. Electrically identical with earlier single and double-ended Aladdin inductors; detailed specifications are available on request.—*Aladdin Electronics, 740 Murfreesboro Rd., Nashville 10, Tenn.*

CIRCLE 147 ON READER-SERVICE CARD

High-Output Strain-Gage Transducer

A new silicon semiconductor strain gage pressure transducer which provides a 250 mv output without an amplifier with 10 v dc to 30 v dc excitation is now available in airborne and ruggedized models from Fairchild Controls Corporation, a subsidiary of Fair-



AIRBORNE SILICON SEMICONDUCTOR Pressure Transducer which requires no amplifier because of its high (1/4 volt) output is only 2.4" long, 1.2" diameter and weighs only 4 ounces.

child Camera and Instrument Corp., and will be on display at the 1961 WESCON show.

Pressure range for the unit is 0-100 through 0-10,000 psi gage or absolute with allowable over-pressure of 1.5 times rated full-scale pressure giving a zero shift of less than ±0.25%. The unit can be used in any gaseous or liquid media compatible with sulfuric anodized aluminum, passivated stainless steel and teflon. Operating temperatures are from —65° to 250°F. Standard compensated temperature range is 0° to 150°F, but compensation can be provided over all the operable range on request.

East Coast headquarters for Fairchild Controls Corporation is at 225 Park Ave., Hicksville, L. I., N. Y. West Coast plant is at 6111 East Washington Blvd., Los Angeles, Calif.

FOR MORE INFORMATION CIRCLE 148 ON READER-SERVICE CARD

Coaxial Connector Master Guide

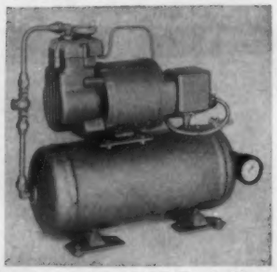
Quick selection of the best coaxial connector to meet application, cable, Mil-Spec requirement and mating connector or adapter is provided by new Master Co-

INDEX TABS save design engineer's time in selection of Connector/Receptacle/Adapter types.

axial Connector Selector which tabulates connectors by Style, Series, Cable Sizes and Types, Receptacles by Mounting Requirements, Adapters by Types, and Adapters between Series by Mating Series and Sex. Mechanical and Electrical characteristics of each series is also listed . . . (*From New 30-page Coaxial Connector Selector Catalog, Automatic Metal Products Corporation, 323 Berry St., Brooklyn 11, N. Y.*)

FOR THIS LITERATURE CIRCLE 149 ON READER-SERVICE CARD

OIL-LESS TANK OUTFIT



New miniature LCT Tank Mounted Unit incorporates the new 1/12 hp piston type, oil-less motor air compressor, and the Piggy-Back air receiver (tested at 100 lbs. pressure). Automatic pressure switch is factory set to cut-in at 25 lbs and cut-out at 40 lbs pressure.—*Bell & Gossett Co., Morton Grove, Ill.*

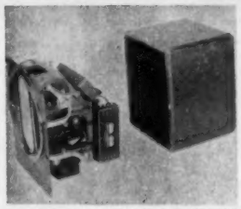
CIRCLE 150 ON READER-SERVICE CARD

AUTOMATIC VTVM

New DYNAMATIC 375-VTVM automatic vacuum-tube voltmeter provides an individual wide-view direct reading scale for each of four ranges. Only one scale is visible at any one time. Once you set the range switch properly, it is impossible to read the wrong scale. Complete specification in catalog sheet AP18 on request.—*B & K Manufacturing Co.*, 1801 *W. Belle Plaine Ave., Chicago* 13, *Ill.*

CIRCLE 151 ON READER-SERVICE CARD

SATELLITE HORIZON SENSORS



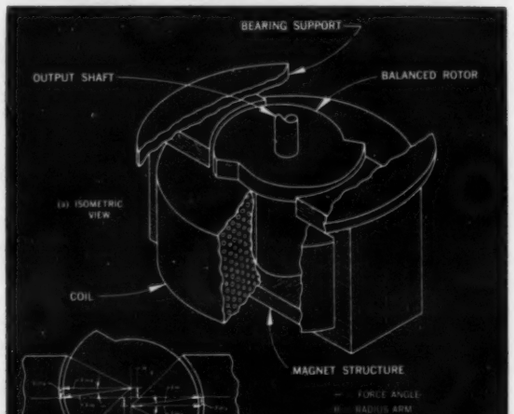
New Series 13-160 All-Altitude Horizon Sensors, sensitive infrared scanning instruments which can detect the sharp thermal discontinuity between the earth's relatively warm atmosphere and the cold background of outer space, for missile and space vehicle applications are sensitive only to the earth's self-emitted radiation, and not to reflected solar emission. Specification Sheet 13-160 is available on request.—*Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.*

CIRCLE 152 ON READER-SERVICE CARD

Rotary Solenoid Actuator

A rotary electric solenoid actuator which has high inherent resistance to mechanical environments such as axial vibration and shock, and originally designed to operate rotary switches in missile and rocket operations, is now available for industrial as well as other military applications.

The construction of the rotary solenoid is diagramatically shown in the figure. Energizing the solenoid coil sets up a magnetic flux in the magnetic frame structure, through the rotating solenoid core and the balanced rotating armature across the armature air gap. Magnetic flux across the air gap causes rotation of the armature against a set of springs in which mechanical energy is stored.



As the balanced rotor nears the limit of its rotation a set of interrupter contacts breaks the input signal, de-energizing the coil. The stored energy of the spring indexes a self-locking ratchet attached to the output shaft and returns the balanced rotor to its original position.

Referring to the force diagram, the magnetic force acting on the center rotor is designated F_m. It acts on a point displaced from the center of rotation by a distance R. The torque acting on the rotor is

$$T = 2\,R\,F_m \cos\theta$$
$$= 2\,F_{mx}\,R$$

where F_m = Magnetic Force; R = Radius Arm; F_{mx} = effective component of magnetic force; θ = Force Angle

This is pure rotary motion. The rotor, being symmetrical, is inherently balanced. The "y" components of the magnetic forces are counter-balanced so no axial force exists on the rotor.

The Model 27 solenoid, supplied with windings of 24 to 30 gauge wire, gives maximum torques of 120 oz-in down to 80 oz-in and with duty cycle limits from 10% to 50% . . . (*From 4-page brochure, Rotary Solenoids, Singer-Bridgeport Div., The Singer Manufacturing Company,* 915 *Pembroke St., Bridgeport* 8, *Conn.*)

FOR THIS LITERATURE CIRCLE 153 ON READER-SERVICE CARD

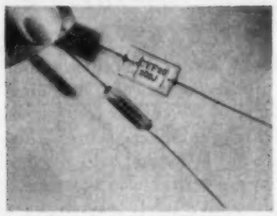
WESCON Previews—

MULTICHANNEL RECORDER

New Magnasync Model T-1510 multichannel recording system for recording 10 channels on ½" tape for as long as 34 hours on one roll of tape. "Fail-Safe" feature detects mechanical or electronic failure and starts standby recorder. No important transmissions are lost.—*Magnasync Corporation, 5546 Satsuma Ave., North Hollywood, Calif.*

CIRCLE 154 ON READER-SERVICE CARD

SEALED GLASS CAPACITORS



New fusion-sealed moisture resistant glass capacitor, Type CYF-20, has a capacitance range from 560 to 5100 pf—over four times larger than previous fusion-sealed types. The CYF-20 shows negligible change from boiling in salt water for 450 hours or exposure to radiation of 10^{18}NVT$_{th}$. Temperature coefficient of capacitance is 140 ±25ppm/°C from −55° to 125°C; DCVW is 300v or more; requirements of MIL-C-11272B are met or exceeded.—*Corning Electronic Components Div., Corning Glass Works, Bradford, Pa.*

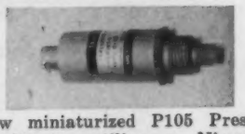
CIRCLE 155 ON READER-SERVICE CARD

C-BAND OSCILLATOR DEVELOPMENT

A new microminiature C-Band oscillator, ¾" in diameter and ⅜" long, for plate pulse and CW service is in advanced developmental stage. Designated Trak Type 9180, developmental models are available on limited basis for experimentation. Peak pulse power is 50 to 100 watts, tuning in any 100mc segment of the 4.0 to 5.5 kmc spectrum.—*Trak Microwave Corporation, Tampa, Fla.*

CIRCLE 156 ON READER-SERVICE CARD

MINI PRESSURE POT



New miniaturized P105 Pressure Potentiometer utilizes a Ni-span-C capsule as the basic sensing element. Less than 4.5 oz weight and only 2" long, it measures between the range of 0-10 to 0-350 psia and delivers up to 75 v full scale output without amplification. Technical Bulletin 1045 on request.—*Trans-Sonics, Inc., P. O. Box* 328, *Lexington* 73, *Mass.*

CIRCLE 157 ON READER-SERVICE CARD

MODULAR INSTRUMENTS

New Modular designs in 22 different instruments used as bench or rack models can be quickly incorporated into space-saving systems for microwave frequency and precise time measurements.—*Hewlett-Packard Company,* 1501 *Page Mill Rd., Palo Alto, Calif.*

CIRCLE 158 ON READER-SERVICE CARD

OVENIZED INDUCTOR

New Model OM-101 electrically variable inductor with built-in thermostat and heater holds frequency drift to less than 1% over a wide range of ambient temperatures. One watt of control power varies the OM-101 from a maximum inductance (of 1.6 μh, to 0.4 μh inductance at saturation.—*Vari-L Co., Inc.,* 207 *Greenwich Ave., Stamford, Conn.*

CIRCLE 159 ON READER-SERVICE CARD

PATCH CORDS

New Subminiature Cross-Patch cords "provide positive dependable inter-connection for an unlimited number of multiple circuits in limited space."—*Herman H. Smith Inc.,* 2326 *Nostrand Ave., Brooklyn* 10, *N. Y.*

CIRCLE 160 ON READER-SERVICE CARD

Selecting a Propeller Fan

Fans are customarily rated by either NEMA or NAFM code and the figures of the two ratings are very different for the same specimen of fan. All ratings given by Rotron are actual volume figures as measured on the complete fan assembly and under the specified condition, which resemble closely the conditions under which the customer will normally use the fan in his application.

The volume of air moved should be chosen sufficiently large to limit the temperature rise of the air in the enclosure to the required level. The following convenient formula may be used:

$$T = \frac{3170}{CFM} kw$$

T = Temperature rise in degrees Fahrenheit (1°F = 1.8°C)
CFM = Cubic feet of air actually moved per minute
kw = Power in kilowatts dissipated inside the enclosure

It follows that for 1 kw of heat dissipation and 10°F temperature difference between incoming and outgoing air, a volume of 317 cubic feet per minute should be flushed through the enclosure. This presumes perfect mixture of the hot and cold air. A slightly higher volume may be desirable to compensate for uneven conditions, although a safety margin is generally already present in the temperature rise figure adopted.

It is not desirable to use a greatly "oversize" fan. The larger volume of air will deposit more dust in the enclosure (even if dust filters are used—see Rotron catalog sheet "On the Use of Dustfilters"). Back pressure will also increase, which is likely to dictate a higher pitched propeller resulting in more air noise. More frequent replacement or cleaning of dust filters is then also required.

For choosing the most suitable fan, the following procedure may be followed:

(1) Establish the required volume of air to be flushed, with the aid of the above formula.

(2) Establish the minimum required dust filter area to be used, with the aid of the information given in Rotron Application "On the Use of Dustfilters" (catalogue sheet 20201-2).

(3) With the aid of the Propeller Fan performance curves for different blades and directions of flow, as given in the Rotron catalog for each type of fan, choose a fan type number which will move approximately the required volume of air under conditions of a dirty dust filter (Fig. 2).

(4) Now, adjust the filter area, if necessary, to increase or decrease the pressure drop and thereby attain more closely the required volume of air.

(5) Check the motor winding temperature rise, under the selected condition of use of the propeller fan, on the Rotron catalog sheet for the particular fan. If the ambient temperature conditions are very high, *Rotron Manufacturing Co., Inc., Hasbrouck Lane, Woodstock, N. Y.*)

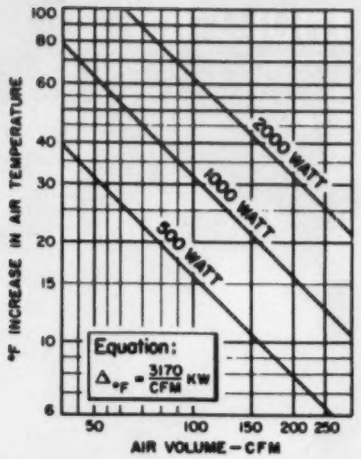


FIG. 1. FAN SIZE is a function of the cooling effect required, which in turn is related to the watts power to be dissipated.

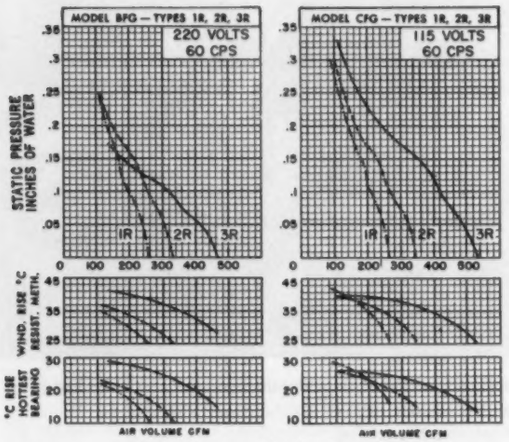


FIG. 2. FAN PERFORMANCE Curves include CFM plotted against static pressure, against winding rise in °C, and bearing rise in °C. 1L, 2L and 3L graphs refer to three different styles of blades which move air in direction "L" (from fan. over the motor). "R" type blades move air away from motor and will show a different series of curves.

it may be necessary to increase the volume of air moved by the fan (by use of a higher pitched propeller or the choice of a larger dust filter), in order to allow for sufficient cooling of the fan motor. For use on government contracts, very high ambient temperatures are generally to be met and it will be found that most Rotron fans are suitable for operation in such high ambients. For exact figures, consult the performance graphs contained in each section in this catalog, which gives full information on the actual winding temperature rise for each model and type of fan over its entire operating range . . . (*From 78-page Catalog RM211, "Green and Red Label Fans and Blowers,*

FOR THIS LITERATURE CIRCLE 164 ON READER-SERVICE CARD

WESCON Previews—

CABLE CLAMPS

New "Lok-Strap" Adjustable Cable Clamps and Cable Ties are available in a new material providing complete flexibility without embrittlement or stretch from −65°F to +225°F, can be opened, closed and re-adjusted repeatedly without damage, without special tools. Bulletin and sample on request.—*Panduit Corp., Dept. IPC 17301 Ridgeland Ave., Tinley Park, Ill.*

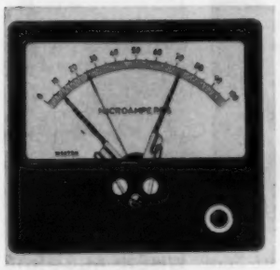
CIRCLE 161 ON READER-SERVICE CARD

LOW COST POWER TRANSISTOR

New 2N2048 low-price MADT using a special filler provides 150 mw power dissipation, exhibits 0.050 saturation voltage, with gain bandwidth product (f_t) of 150 mc in TO-9 case. Is designed for saturated switching circuits used in high speed computer logic and automation equipment.—*Philco Corp., Lansdale Div., Lansdale, Pa.*

CIRCLE 162 ON READER-SERVICE CARD

DOUBLE-ACTION RELAY



New MagTrak relay combines load current contact aiding (LCCA) and magnetic contact aiding acitons, permits relay adjustments to very close tolerances and makes possible the handling of much lower voltage loads without circuit re-design.—*Daystrom, Inc., Weston Instruments Div., 614 Frelinghuyson Ave., Newark 12, N. J.*

CIRCLE 163 ON READER-SERVICE CARD

BRAKE-CLUTCHES

New 28 vdc electrical brake-clutch units in sizes 8 and 11 have standard BuOrd mountings and coaxial input-output shafts.

	length	torque	response time	max. wt.
Size 11	1.839"	16 oz-in	23 msec	5 oz
Size 8	1.530"	8 oz-in	12 msec	2.5 oz

—Bowmar Inst. Corp., 8000 Bluffton Rd., Fort Wayne, Ind.

CIRCLE 165 ON READER-SERVICE CARD

RF WATTMETERS AND LOAD

New Model 6254 Termaline RF Wattmeter and Load designed to measure power output and to terminate low power 50-ohm systems, provides direct power readings over the range of 30 to 500 mc with less than 1.15 VSWR. Any one of six standard ranges from 25 to 100 mw may be specified.—*Bird Electronic Corporation, 30303 Aurora Rd., Cleveland 39 (Solon), Ohio.*

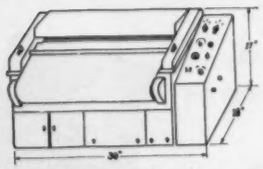
CIRCLE 166 ON READER-SERVICE CARD

COAXIAL MADT AMPLIFIER

Production Models of new microwave MADT Transistor providing a typical power gain of 10 db at 1000 mc is housed in a coaxial package for use as a UHF amplifier.—*Philco Corp., Lansdale Div., Lansdale, Pa.*

CIRCLE 167 ON READER-SERVICE CARD

DEPTH RECORDER



New Model 418 Survey Depth Recorder using the standard 19" Alden recording head gives resolution at 400 fathoms of better than ±1 fathom. —*Alden Electronic & Impulse Recording Equip. Co., Westboro, Mass.*

CIRCLE 168 ON READER-SERVICE CARD

Miniature Photoelectric Chopper

The Photoverter® photoelectric modulator is a non-mechanical device using light modulated photosensistors which are alternately switched on and off by an ac-driven internal light-energy source. The photosensistors, varying in resistance with the change in

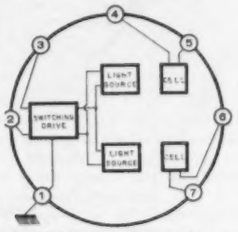


FIG. 1. PHOTOELECTRIC Modulator achieves low-noise in miniature package by light modulation of photosensitors by internal light sources. Schematic of device is at right.

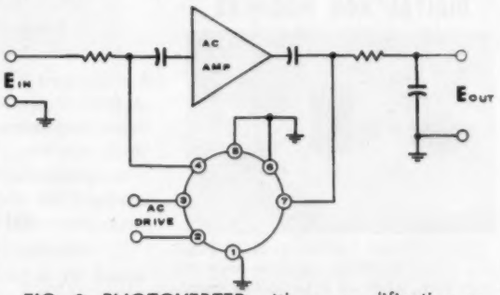


FIG. 2. PHOTOVERTER with ac amplification as here shown, is said to provide gain stability better than that of dc amplifiers by at least an order of magnitude.

light-energy, modulate the input dc signal as a function of the drive frequency (Fig. 1).

The Photoverter is an inertialess unit which will photo-electrically modulate high- or low-level input signals, converting them into a modified square wave. It may also be used to demodulate ac signals to dc. The modulator will operate over a 0 to 25kc drive frequency range (Fig. 2). Careful internal shielding minimizes pickup of external electromagnetic noise. The low noise characteristic makes it particularly adaptable to applications where microvolt-level modulation is required.

The Photoverter has no moving parts and will operate in any position. When drive voltage is discontinued, the modulator is OFF; both switches remain in the open position, preventing the usual circuit loading common to mechanical choppers.

The Photoverter sets a new standard for production modulators, providing the design engineer with a solid-state unit small in size (¾" dia. by 1.16" high), light in weight (10 grams), rugged in construction, producing field performance formerly achieved only in the laboratory . . . (*From 4-page eem file folder, "Photoverter," Photocron Instruments, Inc., 662 Main St., Westbury, N. Y.*)

FOR THIS LITERATURE CIRCLE 169 ON READER-SERVICE CARD

SONIC CLEANING SYSTEM

New Model SEC-1420 Sonic Energy Cleaning System uses 1500 watts to transducers, matching rinse and dryer cabinets.—*Pioneer Central Div., The Bendix Corporation, Davenport, Iowa.*

CIRCLE 170 ON READER-SERVICE CARD

RATIO TRANSFORMER

New Model RT-60, general purpose ratio transformer is a precision inductive ac voltage divider featuring high input impedance; operating range is 50 cps to 10kc.—*Gertsch Products, Inc.,* 3211 *So. La Cienega Blvd., Los Angeles* 16, *Calif.*

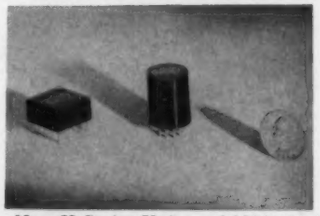
CIRCLE 171 ON READER-SERVICE CARD

AC TIMING MOTOR

New 46100 Series reversible synchronous motor for operation on 115 v 50 or 60 cps is offered in 150 different output speeds from 300 rpm to 1/6 rph, delivers 30-oz-in torque in either direction at 1 rpm. Fast starting, stopping and instant reversal are featured.—*A. W. Haydon Co., Waterbury, Conn.*

CIRCLE 172 ON READER-SERVICE CARD

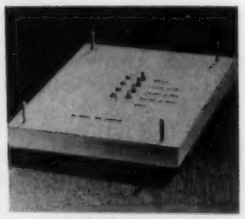
DIGITAL NOR MODULES



New U-Series Universal NOR Digital Circuit Modules operate over the frequency range of 0 to 25 kcs, meeting the requirements of MIL-STD-202B. First Four units are: 1) Dual 3-input NOR; 2) power driver; 3) converter unit to convert dual NOR unit into flip-flop, one-shot or free-running multivibrator; and 4) a pulse gate unit.—*Engineered Electronics Co.,* 1441 *E. Chestnut Ave., Santa Ana, Calif.*

CIRCLE 173 ON READER-SERVICE CARD

DELAY LINES



New magnetostrictive delay lines offering longer delays in smaller sizes and increased temperature ranges will be demonstrated with a dynamic delay of pulses from a word generator with a visual readout. Models 192, 157, 158 and 159 fixed output delay lines, also adjustable time and multiple output laboratory models will be shown at WESCON.—*Deltime Inc.,* 608 *Fayette Ave., Mamaroneck, N. Y.*

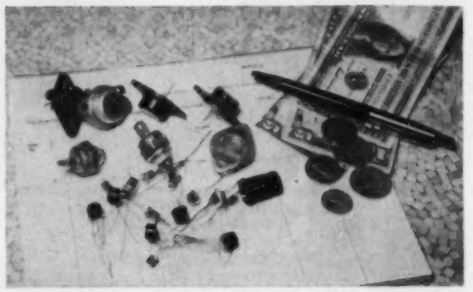
CIRCLE 174 ON READER-SERVICE CARD

Semiconductor Testing Reduces Circuit Development Costs

Six specific cost-saving applications of proper semiconductor analyzers, each application preceding actual circuit development, are:

1) The determination of transistor characteristics under conditions not given on manufacturer's specification sheets. Quick checks can provide needed information not covered in published data.

2) Test of specific components to ascertain they are good, typical, units. Such a test should precede bread-



board construction and also be repeated during development to ensure that component characteristics have not been inadevertently changed. A breadboard may not work, not because the circuit is unsound, but because a component is faulty. Changing suspected parts is not enough. The writer once wasted three valuable days because three 6SH7 tubes from new stock were defective.

3) Selection of maximum and minimum units, as determined by a parameter-measuring test set, in order to check circuit operation over the widest range of semiconductor performance that may be encountered. A set of high and low transistors, selected in the light of the requirements of the project, should be a constantly used development tool.

4) Measurement of the distribution of gain, leakage and other values in semiconductor shipments as received so that realistic compromises between circuit performance and semiconductor cost can be made. Decision as to limits, tolerance and type selection are much easier to make when based on definite knowledge of what variations to expect.

5) Salvaging of semiconductor components from completed experiments for further experimental use (See Figure). It does not pay to take a chance on used, untested components, yet at least half will be found to be undamaged. A very modest development program will have annual savings of $500 or more.

6) More rapid education of laboratory personnel in the ways of transistors and diodes and their variations with current, voltage and temperature. It is most instructive to see the exact change in one parameter as another is varied, or as a warm soldering iron is held near the unit under test. New purchasers are invariably pleased to discover the amount of information that Owen analyzers give with each test. The result is better circuits in less time . . . (*From 8-page brochure, Owen Laboratories, Inc.,* 55 *Beacon Place, Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 175 ON READER-SERVICE CARD

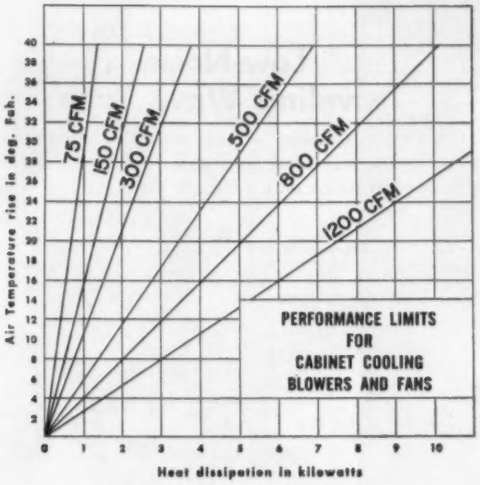


FIG. 1. Graphic Solution for Equation (2).

Forced Air Cooling for Electronic Equipment

Velocity of Air Required

Local hot spots will be created if the air moves too slowly past concentrated heat sources. The heat to be removed must pass from the hot body to the cooling air through an air film surrounding the hot body, and this air film offers most of the resistance to the flow of heat to the air by conduction. The amount of heat removed from the hot body in BTU per minute is:

$$Q = h_c A (t_b - t_a), \qquad (1)$$

where the film coefficient $h_c = 1+0.22V$, for $V < 16$ fps. $h_c = 0.53V^{0.8}$, for $16 < V$ 100 fps air velocity. A = hot surface area in square feet, t_b and t_a are the body and air temperatures in degrees Fahrenheit.

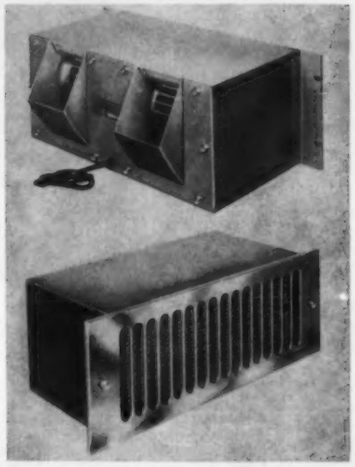
Most components will be adequately cooled if there is an adequate amount of air to carry the heat away with a moderate rise in air temperature.

Quantity of Air Required to Carry Away Heat

The designers must know the amount of dissipated heat which they desire removed and the temperature rise desired for the coolant. The equation relating the variables is $Q = MC_p\ (\Delta\ t)$, or the heat removed equals the weight of the coolant times the specific heat of the coolant times the temperature rise of the coolant. If this equation is applied to air at room conditions on a rate basis, it reduces to:

$$\text{cfm} = \frac{\text{Btu/hr}}{1.08(\Delta t_F)} = \frac{3170\ \text{kw}}{(\Delta t_F)} = \frac{\text{Btu/hr}}{1.94(\Delta t_c)} = \frac{1760\ \text{kw}}{(\Delta t_c)} \qquad (2)$$

for the cubic feet of air required per minute when the heat to be removed is known in Btu/hr or kilowatts and when the permitted average air temperature rise is known in Fahrenheit or Centigrade degrees. In order to insure adequate cooling in air pockets it is well to use about 25% excess air. A common design temperature rise is 10°C or 18°F.



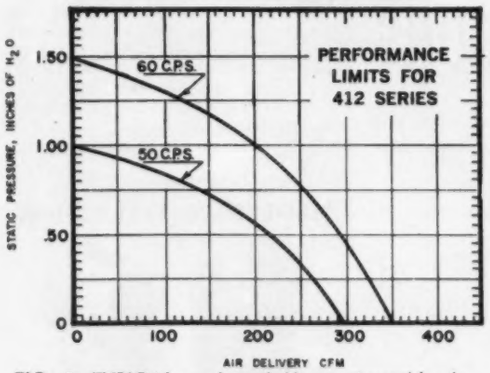


FIG. 2. TYPICAL packaged Blower Assembly delivers 200 cfm at 1" H_2O to 350 cfm at zero pressure differential.

The graph (Fig. 1) enables the designer to solve the above equation graphically for the required cfm when the heat dissipation in kilowatts of the equipment to be cooled is known and the average air temperature rise is selected.

Air Pressure Required

Differential pressures of several inches of water column are sometimes needed to force air at the desired velocity through small or high resistance passages, which can be determined by analysis or test.

It is costly to specify more differential pressure than needed because the driving power required increases very rapidly. This extra power requires an appreciably larger and heavier motor and often a larger and heavier cabinet or support. Pressures specified should not be in excess of actual needs.

Vacuum tube assemblies normally provide enough free passage area for the air to flow so that the required differential pressure is seldom over an eighth inch of water plus the pressure drop across the filter. The rating of McLean packaged assemblies (Fig. 2) is made with filter, grille, and enclosure in place. Miniaturized assemblies using solid state components, because of small clearances, often require higher pressures. . . . (*From 42-page 21st anniversary catalog and design guide for Electronic Cooling Equipment, McLean Engineering Laboratories, Princeton, N. J.*)

FOR THIS LITERATURE CIRCLE 176 ON READER-SERVICE CARD

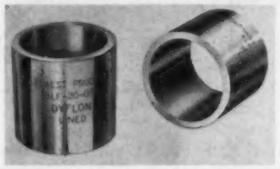
WESCON Previews—

SOLENOID VALVE

New Three-way Two-position direct actuated poppet type Aircraft Quality Solenoid Valve for use in rocket systems has been qualified for use with air, helium, hydraulic oil, hydrogen peroxide, fuel, anhydrous ammonia, UMDH, IRFNA, etc., depending on elastometers used in O-rings. —Solenoid operates at 17-30 v dc.— *Captive Seal Corporation, 121 Clinton Rd., Caldwell, N. J.*

CIRCLE 177 ON READER-SERVICE CARD

SELF-LUBE JOURNAL BUSHINGS



New plain self-lubricating journal bushings of stainless steel lined with "Dyflon" plastic alloy inserts are capable of dynamic loads to 25, psi at low rotational speeds. Life at 10,000 psi with speeds less than 150 ft/min is said to be practically unlimited, without galling, fretting or brinelling. —*Southwest Products Co., 1705 So. Mountain Ave., Monrovia, Calif.*

CIRCLE 178 ON READER-SERVICE CARD

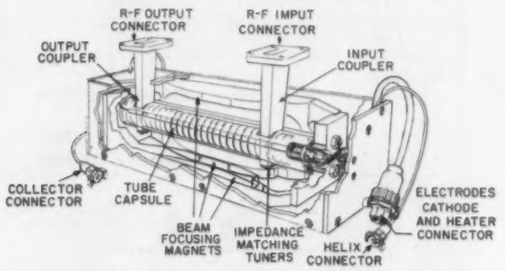
POWER-LOCK HANDLE

New Thumb-Action Power-Lock Drawer Handle ensures accurate alignment of rear connectors in cabinets housing electronic rack-mounted chassis. Cam action levers apply 6.6:1 advantage in insertion and withdrawal of last ¾" of drawer travel. —*Johnathan Manufacturing Co., Fullerton, Calif.*

CIRCLE 179 ON READER-SERVICE CARD

Low-Noise Traveling Wave Tubes

The high reliability of G-E low-noise traveling-wave tubes makes them ideal for a wide variety of systems applications of which only a few are listed.



PERMANENT Magnet TWT Package in Cutaway View.

Radar. Because of their inherent low-noise figure over large bandwidths, these tubes are especially suited for use as input tubes in radar receivers. Also, due to their saturation characteristic, they protect the crystal mixer by isolating it from the high-power components of the radar system.

Countermeasures. The wide spectrum and low signal-to-noise ratio permit rapid surveillance over the entire microwave spectrum in countermeasure equipments.

Telemetering and Communications. Tuning linearity, amplitude control capability, and flat output characteristics permit considerable advances in new and existing telemetering and communications equipment. Pulse, amplitude and phase modulations are readily accomplished.

Missiles, Aircraft, Space Vehicles and Drones. Compact size, rugged construction, high reliability and packaging features make the tubes particularly effective in aerospace systems applications (see Figure).

Other microwave applications for low-noise traveling-wave tubes include radio-astronomy, electronic mapping, relay systems, signal sources, and mixer and frequency dividers.—(*From 16-page bulletin, "Low-Noise TWT," General Electric Co., Power Tube Dept., Schenectady 5, N. Y.*)

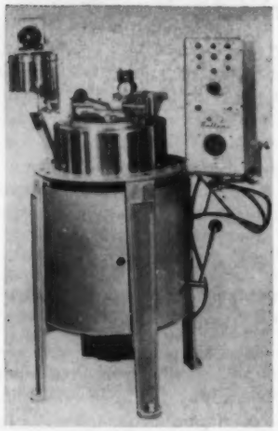
FOR THIS LITERATURE CIRCLE 180 ON READER-SERVICE CARD

VARIABLE FREQUENCY GENERATOR

New line of Variable Frequency 3-Phase Electronic Generator covers output powers ranging from V.A. thru 3,000 V.A. Typical Model 150-3 (illustrated) has frequency range of 45 to 2,000 cps and a total output power of 480 V.A. Output distortion and regulation are less than 1%. Units are also available with standard 350-450 C.P.S. frequency range. —*Industrial Test Equipment Co., New York, N. Y.*

CIRCLE 181 ON READER-SERVICE CARD

CRYSTAL LAPPERS



New precision planetary lappers for semiconductor crystal processing, are capable of lapping both faces of a slice simultaneously with parallelism in the order of 0.000005" from the center to the edge of the slice. Model PL-2875-B (illustrated) will lap 10 slices, up to a maximum size of 1¾" diameter or 60 smaller sizes, to a thickness of 0.008".—*Dallons Labs., 5066 Santa Monica Blvd., Los Angeles 29, Calif.*

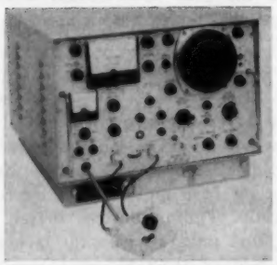
CIRCLE 182 ON READER-SERVICE CARD

ACCELERATION SWITCH

New Planar Acceleration switch can be produced in unlimited variety of vector acceleration patterns, including reentrant curves, sensitive to pre-determined vector accelerations in the range of 0.25 to 100 G.—*Aerodyne Controls Corp., 90 Gazza Blvd., Farmingdale, L. I., N. Y.*

CIRCLE 183 ON READER-SERVICE CARD

SWITCH-TIME TESTER



New automatic switching time-test instruments to the semiconductor and computer industry covering times of 1 nsec to 1 μsec, includes an oscilloscope with 800 mc bandwidth for observing the actual switching waveform.—*Wiltron Co., 717 Loma Verde Ave., Palo Alto, Calif.*

CIRCLE 184 ON READER-SERVICE CARD

CIRCLE 64 ON READER-SERVICE CARD ⟶

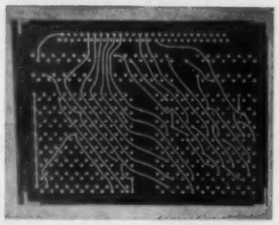
SCHERING BRIDGE

New Hartmann & Braun SCHERING BRIDGE Model MES 8 for accurate measurement of the dielectric loss factor tan delta and the capacitance of ungrounded or grounded test objects at high and low voltage, and for the determination of the lielectric constant of solid and liquid insulating materials.

Measuring range for capacitance is from 3 pf to 35 μf and for tan delta from 2 x 10^{-4} to 5.0. Shown in Booth 3305-07.—*Sole U. S. Distributor, E P I C, Inc.,* 150 *Nassau St., New York* 38, *N. Y.*

CIRCLE 185 ON READER-SERVICE CARD

PRINTED CIRCUITS



New technique in multi-layer printed circuitry providing space saving of 60% requires no soldering, riveting or conductive pastes for cross-over connections. Cross-over connections are internal and metallurgically bonded to each other.—*Scientific Components Div. of Intellux, Inc.,* 30 *South Salsipuedes St., Santa Barbara, Calif.*

CIRCLE 186 ON READER-SERVICE CARD

ULTRASONIC CLEANERS

New "SC" (semiconductor) self tuning generator (left) is controlled with former tube-model of same capacity on right. Operating on 20-kc frequency, with powers rated at from 100 to 2500-watts, in standard off-the-shelf line. Tank sizes range from 1 to 25 gallons.—*Acoustica Associates, Inc.,* 10400 *Aviation Blvd., Los Angeles* 45, *Calif.*

CIRCLE 187 ON READER-SERVICE CARD

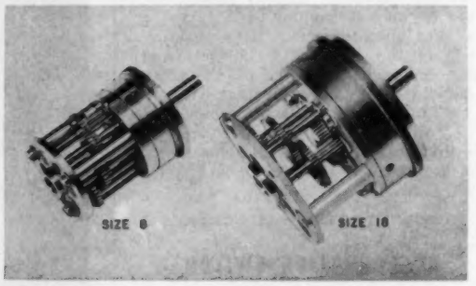
Gearhead Ratios

The choice of a gearhead gear ratio is made by the servo-mechanism designer. The important consideration here is whether the ratio is selected on the basis of matching motor to load, or whether ratio is determined by considerations of loop gain. The list below summarizes some of the factors influencing the choice of gear ratio. Ample margin should be provided to account for variations in servomotor characteristics.

Factors in Gear Ratio Selection

1. When the reference signal varies at a relatively constant speed, the gear ratio should permit following at this speed.

2. When the reference signal experiences sudden increments (high acceleration) the gear ratio should be selected to achieve maximum torque-to-inertia ratio at the output.



3. Where static accuracy or slow smooth following is a principal consideration, the gear ratio should amplify motor torque so that the output torque is capable of maintaining the error within allowable limits. This gear ratio is usually inefficient in terms of power transfer to the load.

4. When there are special requirements such as the ability to maintain simultaneously a specified velocity and acceleration, or the need for rapid reversal, or the requirement of minimum time to come up to speed, or a maximum allowable braking time, the gear ratio must be determined accordingly.

5. When a specified friction load is to be carried at a given speed, (either a constant friction or a linear speed-varying drag,) the gear ratio should suitably match the motor maximum power output point to the load speed.

Once the overall ratio is established, the gearhead manufacturer matches this as closely as possible with one of his standard models (See Figure). For this reason some tolerance is necessary on the specified ratio. An "exact" ratio requirement, calling for a non-standard gear design, costs more than an approximate yet suitable ratio. Timing devices driven by synchronous motors, and integrating motor tachometers, however, often require exact ratios. (*From* 25-*page catalog* 600-1, *Precision Gear Heads, Speed Reducers, Servo Systems, Gear Trains," Superior Manufacturing & Instrument Corporation,* 36-07 20*th Avenue, Long Island City* 5, *New York.*)

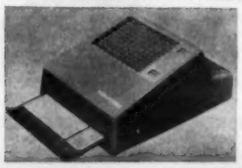
FOR THIS LITERATURE CIRCLE 188 ON READER-SERVICE CARD

AUTOMATIC COUPLINGS

New series automatic couplings for fuel, hydraulic, oil, and gases feature a modern locking mechanism actuated by a simple "push-to-engage" and "pull-to-discharge" motion include: Series "E" for electronic cooling systems; Series "A", premium reliability series, for aircraft and missile applications, and Series "C" for standard industrial and commercial applications—*Exeter Connectors, Inc., 93 Court St., Exeter, N. H.*

CIRCLE 189 ON READER-SERVICE CARD

DATA ACQUISITION SYSTEM



New Model 87-210-01 Input Station receives card, badge, variable, fixed and remote data, and transmits it to a DL-210 Central Recording Station. The input station includes a reader capable of receiving up to 80 digits of pre-punched card data and 10 digits of pre-punched badge data.—*Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.*

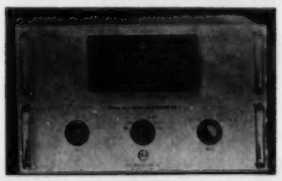
CIRCLE 190 ON READER-SERVICE CARD

MAGNETIC LATCHING RELAY

New series AM micro-miniature sealed relays are magnetically latched for operation from short power pulses. New "Matched action" prevents sluggish action. Both single-and-dual-coil units are available.—*General Electric Company, 392 So. Stratford Rd., Winston-Salem, No. Carolina.*

CIRCLE 191 ON READER-SERVICE CARD

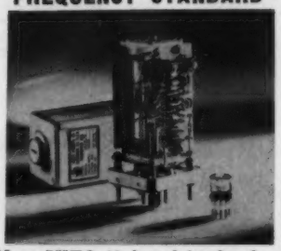
DIGITAL VOLT-OHM METER



New Model M25 5-Digit Voltmeter —Ohmmeter measures voltage with an accuracy of ±0.01% of reading ±1 digit in ranges of ±9.9999 to 999.99 volts, voltage ratio in ranges of .99999 to 99.999, and resistance in ranges of 9.9999 to 999.99 kilohms.—*Non Linear Systems, Del Mar, Calif.*

CIRCLE 203 ON READER-SERVICE CARD

FREQUENCY STANDARD



New JKTO-42 low-drive-level, current limiting osciillator designed for laboratory or plant environment for frequencies up to 5 mc, also new crystals, crystal ovens will be displayed at Wescon.—*James Knights Co., Sandwich, Ill.*

CIRCLE 193 ON READER-SERVICE CARD

RATE TABLE DRIVES

Tach generators are available over a wide range of voltage gradients. Combination torque motor-tach generator units assembled in their own housing, completely shielded and mounted in precision bearings are also available for mounting directly to test tables. The life of such equipment is in excess of 5000 operating hours without overhaul of maintenance.—*Inland Motor Corporation of Virginia, Subs. of Kollmorgen Corp., Northhampton, Mass.*

CIRCLE 194 ON READER-SERVICE CARD

MAGNETIC AMPLIFIER

New Preac Amplifier, Type M-5851-C provides a 5 v dc polarity-reversible output with low level inputs such as obtained from thermocouples, strain gages and photocells. Input winding resistance is temperature stabilized for operation from −40° to 85°C. Requires only 2 watts power from 115v 400cps supply.—*Airpax Electronics Incorporated, Seminole Div., Fort Lauderdale, Fla.*

CIRCLE 195 ON READER-SERVICE CARD

MOTORIZED MIXING VALVE

New 21300 Series Mixing Valves control flow from hot and cold inlet ports through cylinder segment which rotates on bearings. Ball bearing suspension allows use of high response servo motor with electrical leads brought out through glass header. Motor, gears and valve operate at system pressures up to 3000 psi.—*Aerodyne Controls Corp., 90 Gazza Blvd., Farmingdale, L. I., N. Y.*

CIRCLE 196 ON READER-SERVICE CARD

Modulation and Demodulation Using "Chopperettes"

VECO "Chopperettes" are completely transistorized switching devices, designed to perform low level modulation (chopping) or demodulation. Bring solid state devices, there are no contacts to bounce, chatter, pit or wear, and have insignificant cross-over time with dwell periods approaching 180° up to 5 kc.

"Chopperettes" operate from dc to 5 kc with excellent results, and up to 100 kc within limitations imposed by required linearity. When ultra linear (.05%) transfer functions are required, square wave 50% duty cycle driving voltages should be employed.

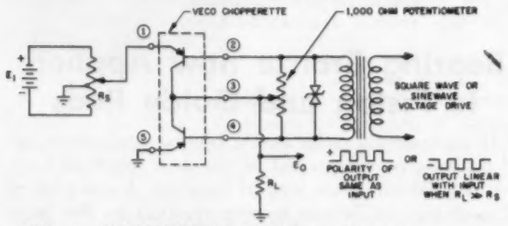


FIG. 1. CHOPPERETTE Modulator Circuit.

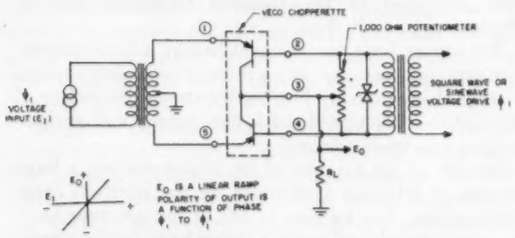


FIG. 2. CHOPPERETTE Phase sensitive Demodulator.

Basic applications are shown in Fig. 1 and 2. The 1000 ohm potentiometer of provides a null balance between the two transistors. Minimum switching noise can be attained by shorting terminals one and five to ground and adjusting the potentiometer until a minimum voltage is observed across R_L. The use of a high-quality, low-noise level VTVM with proper shielding is suggested for this measurement.

As in any low level circuit, precautions should be taken to prevent stray pick-up. Low impedance (under 200 ohms) driving circuits are suggested where ambient electrical noise levels are high.

Transformer choice is based on circuit application. Transformers ranging from inexpensive 6.3V filament types to sector wound, low coupling-capacity toroids have been used successfully. In transferring square wave energy from primary to secondary, droop will be a function of transformer open circuit inductance and load impedance. Since optimum performance is guaranteed *only* on "flat" square wave drive, and by virtue of the fact that all transformers will allow pulse droop, the use of back-to-back Zener diodes is recommended to reshape the drive square wave . . . (*From 4-page brochure, Form V383B, Victory Engineering Corporation, P.O. Box 373, Union, N. J.*)

FOR THIS LITERATURE CIRCLE 197 ON READER-SERVICE CARD

TAPE SYSTEM

New PHD-1200 High Density Magnetic Digital Tape System reads and writes tapes at packing densities of 1,200 bits/inch with transient error rates less than 1 bit in 10^9 and permanent error rates less than 1 bit in 10^{10}.—*Potter Instrument Company, Inc., Sunnyside Blvd., Plainview, N. Y.*

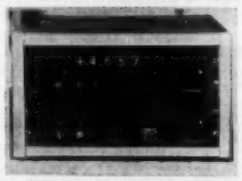
CIRCLE 198 ON READER-SERVICE CARD

WHISPERING AIR FAN

New Series 599YS Aximax fan designed for extremely low-level noise when operating on 115 v 60 cps single phase power moves approximately 24 cfm at free delivery. Servo ring mounting is only 3" diameter, 2¼" deep.—*Rotron Manufacturing Co., Inc., Woodstock, N. Y.*

CIRCLE 199 ON READER-SERVICE CARD

DIGITAL MULTIMETER



New digital multimeter combines a Voldicon V16-AD basic voltage to digital converter with a multi-purpose signal conditioner and programming accessory modules to measure absolute ac or dc values or voltage ratios between dc and dc, ac and ac or ac and dc in any combination. Operating modes and ranges may be selected by manual switch or by remote signal programming. Unlimited applications in automatic checkout systems.—*Adage Incorporated*, 292 *Main St., Cambridge* 42, *Mass.*

CIRCLE 200 ON READER-SERVICE CARD

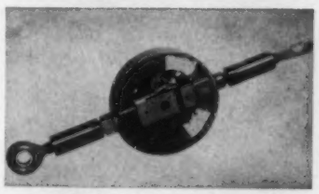
WESCON Previews—

TRANSISTOR TEST COUNTER

New Transistor Fault Counter Model C-10 displays the total number of transistors tested on the indicator labeled "STARTS". Indicators 1-10 display the number of transistors which do not pass tests 1-10, which may be standard transistor measurements, such as ICBO, IEBO, VBE, VCE Sat., HFE, alpha, beta, etc.—*Optimized Devices, Inc.*, 864 *Franklin Ave., Thornwood, N. Y.*

CIRCLE 201 ON READER-SERVICE CARD

LOAD TRANSDUCERS



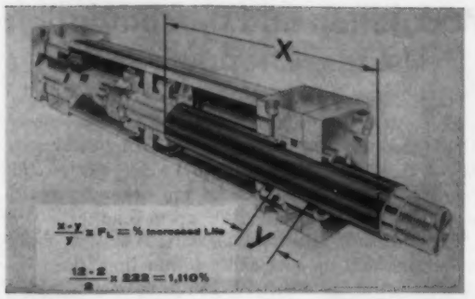
New Load Cells designed to measure both tension and compression in seven models with full load ratings from 1000, to 100,000 pounds are standard. Temperature compensation provides high stability in rapid changes in temperature, even where there is a steep temperature gradient across the transducer. The units can be used without damage from −300°F to 750°F.—*Microdot Inc.*, 200 *Pasadena Ave., South Pasadena, Calif.*

CIRCLE 202 ON READER-SERVICE CARD

HIGH PERMEABILITY MAGNETWIRE

New Netic, Co-Netic AA and Co-Netic B alloy wires with high permeability offer a lower reluctance path to the magnetic flux concentrating the field in transformer and other inductance applications. For a given coil or transformer, the number of turns and wire diameter can be reduced and still result in an equivalent resistance and inductance.—*Magnetic Shield Div., Perfection Mica Co.*, 1322 *No. Elston Ave., Chicago 22, Ill.*

CIRCLE 203 ON READER-SERVICE CARD



BRONZE COATED piston rod in steel bushing affords increased bearing life. Factors in bearing life computation are increased bronze wearing surface ratio and enhanced lubrication factor.

Bearing Bronze now Applied to Piston and Guide Rods

In conventional reciprocating bearing applications, all of the wear is concentrated on the short length of bearing material within the support bushings. A new method of applying the bronze bearing material to the large area of the shaft instead, and called Bronze Case, has been developed by the Thomson Industries, Inc., of Manhasset, L. I., N. Y.

The bronze fusing is accomplished by a high-temperature spraying operation which forms a controlled porosity coating of high quality bearing bronze on the surface of the steel rod. The coated rod is then ground and straightened to very close tolerances.

Because of the porosity of the bronze coating, a large amount of lubricant is retained on the relatively large shaft surface. The increase in life of the new type bearing over conventional types is shown by a simple calculation.

The factors determining the life of the reciprocating bearings are given in the formula

$$\frac{x-y}{y} F_L = \% \text{ Increased Life.}$$

where $x - y =$ length of stroke, $y =$ bushing length, and F_L is a lubrication factor, which expresses the improvement due to greater lubricant storage and to the fact that the lubricant is not pushed to the end of the stroke.

Comparative tests have shown that the F_L factor is a function of the frequency and amount of lubrication applied to the shaft surface. In applications providing frequent and copious lubrication, the F_L factor can be as low as 100, which means no improvement over that provided by the $x - y/y$ ratio. In the case of infrequent lubrication, an F_L factor of 444 is indicated. In the example shown in the figure, an F_L factor of 222, which assumes periodic lubrication under average conditions, was used. Thus, in this application, life is increased more than ten-fold.

Standard hardened steel die set bushings are used with Bronze Case rods in many applications. Standard drill bushings are also excellent. Both these types of bushings are available from stocks of local die supply or mill supply houses. (*From 2-page bulletin "Bronze Case" Thomson Industries, Inc.*, 1029 *Plandome Road, Manhasset, L. I., N. Y.*)

FOR THIS LITERATURE CIRCLE 204 ON READER-SERVICE CARD

Sun Sensor

ATTITUDE ORIENTATION toward the sun is automatically provided by new sun sensor which feeds displacement signals to actuate space craft stabilization controls. Sensor is 2¼" in diameter, 5" long and weighs only 5½ oz, complete with its own preamplifier.

A novel Sun Sensor, developed by the Eclipse-Pioneer Division of the Bendix Corporation, Teterboro, N. J. As a precise means of sensing and locking to the sun for space craft attitude control and orientation, will be on display at WESCON 1961.

The Sun Sensor utilizes a single four-section photodetector as its only active element, combined with a unique optical system to provide proportional displacement error signals. The error signals are amplified to actuate stabilization controls such as the Bendix Reaction Wheel. The Sun Sensor is a primary reference for attitude, with an accuracy of ±0.05°.

The active element is a circular four-section array of balanced silicon photovoltaic cells mounted on a heat sink. Outputs of the individual cells are summed to provide x-y coordinate information. The optical system projects sunlight on the detector elements to produce output signals. This is achieved through four light pipes that are arranged above the detector elements, each pipe having a coverage area of 90° in azimuth and 82.5 degrees in elevation. The pipes are spiralled 180° to obviate the need for an image-inversion lens.

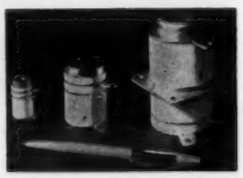
The sunlight incident upon the face of the pipes is directed to the outer periphery of the appropriate detector elements. The amount of light transmitted and therefore the signal outputs are in inverse proportion to the sun's elevation angle. Through proper shaping and diffusion coating, the optical gains of the light pipes and the aperature are matched so that there is no irregularity in output as the sun traverses from horizon to null.

Since at null each of the four detector elements has an output, a self checking feature may be incorporated.

FOR MORE INFORMATION CIRCLE 205 ON READER-SERVICE CARD

HIGH TEMPERATURE DIODES

Three new ceramic, inert gas-filled diodes designed to operate in 500°C ambients are also resistant to nuclear radiation. Pictured from right to left: The 10-amp Z-5437, the 2-amp Z-5434 and the .15 amp Z-5365, all available in sample production.—*Power Tube Dept., General Electric Co., Schenectady, N. Y.*



CIRCLE 206 ON READER-SERVICE CARD

EPITAXIAL HI-SPEED SWITCHES

New compact TO-18 series (NS-381, NS-382, NS-383 and NS-384) NPN Silicon epitaxial switching transistors feature fast switching speeds, high breakdown voltages, low saturation voltages, and low output capacities.—*National Semiconductor Corp., Danbury, Conn.*

CIRCLE 207 ON READER-SERVICE CARD

PANCAKE RESERVOIR

New high precision pancake resolver for use with stable platforms, has integral bearings for direct mounting to the gimbal and has functional accuracy to 10 sec of arc. Performance specifications on request.—*Reeves Instrument Corp., Subsidiary of Dynamics Corp. of America, Garden City, N. Y.*

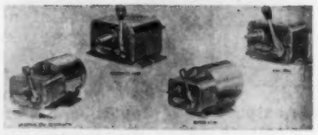
CIRCLE 208 ON READER-SERVICE CARD

SEAL BUTTON CAPACITOR

New welded seal button mica capacitor, with solder-free design permits operation at higher ambients and allows high temperature soldering installation techniques. Capacitance values to 1500 pf are available at 500 wvdc in a variety of mounting configurations, exceeding the requirements of MIL-C-109500B.—*Sangamo Electric Co., Springfield, Ill.*

CIRCLE 209 ON READER-SERVICE CARD

VARIABLE SPEED DRIVES



New "400 Series" Zero-Max variable speed drives for fractional h-p applications feature overload protection, new slipless lever-controlled speed setting, and improved venting of the motor. Information on request covers over 250 types from ⅛ to ¾ hp.—*The Zero-Max Co., 2845 Harriet Ave., South, Minneapolis 8, Minn.*

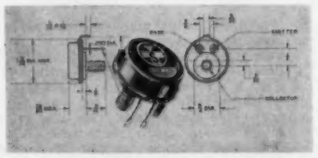
CIRCLE 210 ON READER-SERVICE CARD

CHASSIS FIXTURE

New TD Model A holding device positions and transports electronic chassis for assembly, test and service. Features include adjustable height, fast action clamping, nylon glides and adaptability to wide range of chassis sizes.—*Technical Devices Co., 11242 Playa Crt., Culver City, Calif.*

CIRCLE 211 ON READER-SERVICE CARD

POWER TRANSISTORS



Two new high power transistors, types 2N1015 and 2N1016 diffused junction, NPN silicon devices are 150 watt, single-end stud types with collector-emitter voltages of 100 v; saturation resistance of 0.5 ohms; minimum beta of 10 @ 5 amps.—*Silicon Transistor Corp., Carle Place, N. Y.*

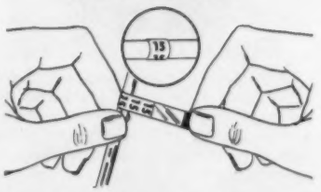
CIRCLE 212 ON READER-SERVICE CARD

MODULAR COOLING PACKAGE

New DELTA-T Model FCA-800 Semiconductor Cooling Package offers thermal resistance as low as 0.5° C/W per semiconductor. Low head loss per unit length and electrically isolated aluminum quandrants permit construction of multiple station packages. —*Wakefield Engineering, Inc., 414 Main St., Wakefield, Mass.*

CIRCLE 213 ON READER-SERVICE CARD

WIRE MARKERS



New E-Z-Code Self-Laminating Wire Markers protect markings from all conventional greases, chemicals, etc. When coded marker is applied to wire the remaining protective clear portion wraps around itself, causing it to laminate permanently over the coded area thus protecting itself. Brochure, *samples* on request.—*Westline Products Div. Western Lithograph Co., 688 East 2nd St., Los Angeles 54, Calif.*

CIRCLE 214 ON READER-SERVICE CARD

FREQUENCY COMPARATOR

New all-solid-state Frequency Comparator, Type 35-2001, accepts any input frequency from 1 cps to 50 kc, compares it with precision reference oscillator. Difference in frequency results in output signal proportional to error to actuate control device.—*Daystrom-Wiancko Eng. Co., 255 North Halstead Ave., Pasadena, Calif.*

CIRCLE 215 ON READER-SERVICE CARD

For More INFORMATION on Products Listed Circle Number on Readers Service Card

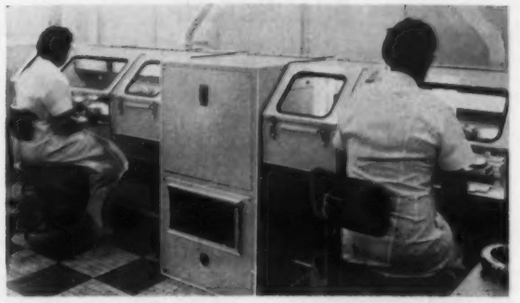


FIG. 1. VAN-DE-GRAAFF Particle accelerators being assembled in Sterilshield Workspaces at High Voltage Engineering Corp., Burlington, Mass.

Dust-Free Production Aids

Modern technology's demands for "impossible" precision and purity are being answered by dust-free workspaces, dry boxes, and pre-fabricated dust-controlled rooms produced by the Baker Company, engineers and manufacturers of Clean Room facilities.

Dust-Free Workspaces. Four standard models of the Sterilshield Workspace (Fig. 1) make precision assembly work possible in hitherto unsuited areas. The Model 110 is a completely self-contained portable unit, while Models 112, 113 and 114 are used in conjunction with Sterilshield Air Cleaning Units. With all models, however, the basic principle of operation is the same; air is brought into the system, filtered, and passed on under pressure to the Workspaces. The slightly higher pressure inside the cabinet produces a steady flow of air out through the access opening, creating an impenetrable barrier to airborne lint and dust particles. All models contain two fluorescent lamps and twin 110V utility outlets mounted within the cabinet. Special electric outlets, utility drawers, glove ports, iris ports, microscope bellows, ultra violet lighting, ultrasonics and spray cleaning devices are also available.

Dry Boxes are equipped, as required, with airlocks for ingress and egress to welding, varnishing, assembly, storage, vacuum ovens and other operations (Fig. 2). These units can be arranged to allow parts to be passed from one station to the next via pass-

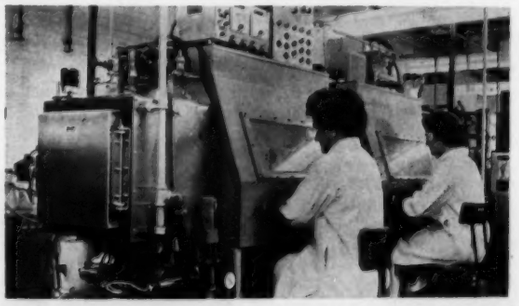


FIG. 2. DRY BOXES provide a dust-, moisture-, and bacteria-free work area for the fabrication of critical semiconductor components at General Transistor Corp. plant, Jamaica, N. Y.

FIG. 3. CLEAN ROOM installation at Sperry-Farragut's Bristol, Tenn. plant. In the entire space visible in this picture there is not enough dust to cover a 4c stamp.

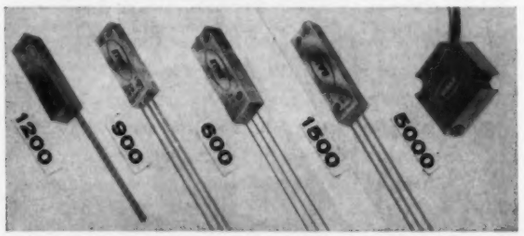
thru locks which can be purged to prevent contaminants travelling through the operations.

Dust-Controlled Rooms. Constructed on the modular building-block principle, Sterilshield rooms (Fig. 3) can be designed and built to any size, to fit any manufacturing process. A typical layout consists of; 1) a gowning room, for storage of clean-room apparel and for dressing; 2) an air shower for dedusting personnel; 3) an air lock for separating the shower from the room, and 4) the clean room itself. The clean area may be further sub-divided into several rooms if the work process so dictates. (*From new 20-page brochure, The Baker Company, Biddeford, Maine and Chandler, Ariz.*)

FOR MORE INFORMATION CIRCLE 216 ON READER-SERVICE CARD

Trimming Potentiometers

New wirewound T-Pots, produced under surgically clean conditions, with temperature and humidity maintained at a constant level, are welded and sealed to provide protection against moisture in use or contamination by potting compounds during subsystems assembly.



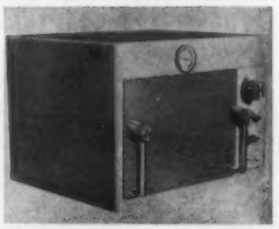
Besides the solid wire leads shown, they are available in a wide selection of terminal configurations. All are rated at 1 watt at 70°C, to 5% tolerance of nominal value.

T-Pot Series	Dimensions (inches)	Range (ohms)	Derate to 0 at
1200	.280 x .310 x 1¼	10 to 50K	150°C
900	.300 x .180 x 1	10 to 30K	175°C
600	.300 x .180 x 1	10 to 30K	175°C
1500	.300 x .180 x 1¼	10 to 50K	175°C
5000	.500 x .190 x 500	100 to 50K	150°C

(*From new 6-page brochure "T-Pots," Dale Electronics, Inc., Columbus, Nebr.*)

FOR MORE INFORMATION CIRCLE 344 ON READER-SERVICE CARD

HOT/COLD CHAMBER



New Miniature High-Low Temperature Chamber, Model C-106, cooled by liquid CO_2, provides faster heating and cooling rates, closer temperature control and distribution, and increased operating economy. Test volume is 640 cu-in. Temperature range is from −100° to 500°F with a control accuracy of ±0.5°F.—*Wyle Laboratories, Inc., El Segundo, Calif.*

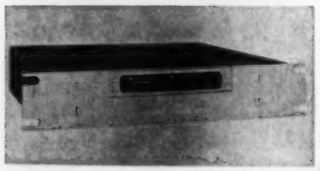
CIRCLE 217 ON READER-SERVICE CARD

DIRECT WRITING RECORDER

New Tracemaster single-channel direct writing recorders are self-contained in attache-size case with separable top cover and weigh just 20 lbs. Three-channel models can be operated in vertical, horizontal or tilted positions and feature interchangeable plug-in type amplifiers. Both models accommodate 200 ft of chart, push-button controlled, to speeds of 1, 5, 20, 100mm/sec and employ direct-carbon transfer writing method. Frequency response dc to 100 cps at 25mm peak-to-peak amplitude, −3db at 125 cps., ±5%.—*American Optical, Instrument Div., Buffalo* 15, *N. Y.*

CIRCLE 218 ON READER-SERVICE CARD

MINI SYNCHRO BRIDGE



Laboratory standard bridges for checking synchros (MSB 5) or resolvers (MRB 5) to 20 ppm accuracy are available in miniaturized models. Both instruments provide measurements in 5° steps from 0-360°. Absolute accuracy from 0-800 cps is .002%. Frequency range extends to 10 kc at reduced accuracy.—*Julie Research Laboratories, Inc.*, 603 *West 130th St., New York* 27, *N. Y.*

CIRCLE 219 ON READER-SERVICE CARD

MINI-RAPID PROCESSOR DEVELOPS DATA DISPLAY FILM RECORDS–FAST!

See your data display film records in minutes. Fairchild Mini-Rapid Film Processors give you automatic delivery of negatives – developed, fixed, washed, dried–commercial quality.

16mm films up to 6 f.p.m.

35mm films up to 4 f.p.m.

Oscillograms, digital or analog display, radar, meters, gauges, controls – any information display that you record on 35 or 16mm film can be read back just a few minutes after your film is inserted into the Mini-Rapid.

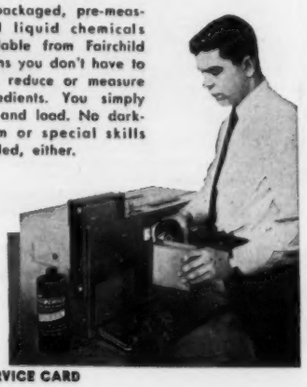
Operation? Easy. Insert a few inches of film into the loading compartment, drop in spool, close door. Automatic transport takes over and does the rest.

Write for illustrated specifications and prices to Industrial Products Division, Dept. MS-8, Fairchild Camera and Instrument Corp., 580 Midland Ave., Yonkers, N. Y.

MINI-RAPID FEATURES

- capacity up to 400 feet
- table top compactness
- dual thermostat control
- completely automatic
- leaderless daylight loading
- self-threading film transport

Pre-packaged, pre-measured liquid chemicals available from Fairchild means you don't have to add, reduce or measure ingredients. You simply mix and load. No darkroom or special skills needed, either.



INDUSTRIAL PRODUCTS DIVISION
FAIRCHILD
CAMERA AND INSTRUMENT CORPORATION

CIRCLE 78 ON READER-SERVICE CARD

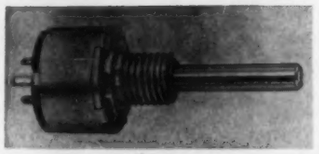
WESCON Previews—

TRANSISTOR ADAPTOR

New Transistor Adaptor having a frequency range of 30 to 3000 mc for use with Z-g Diagraphs for measuring impedance and admittance in microwave circuits to 3 kmc.—*Rohde & Schwartz*, 111 *Lexington Ave., Passiac, N. J.*

CIRCLE 220 ON READER-SERVICE CARD

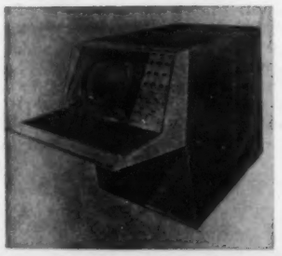
MOLDED CARBON CONTROL



New ½" Series 63M molded carbon potentiometer designed to fill the need for reliability and electrical quietness in better grades of commercial equipment. It will be available in a wide range of resistance values.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

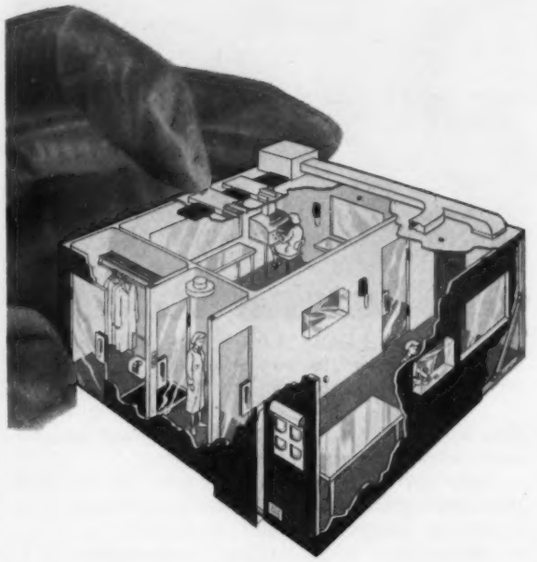
CIRCLE 221 ON READER-SERVICE CARD

DIRECT VIEW DISPLAY



Advanced direct-view display S-C 1090 console, for monitoring digital computers, will be used in command decision making utilizing man-machine information systems where it is necessary to continuously monitor a large store of changing information. Similarly, the console can be used for other systems such as air traffic control, information retrieval and automatic process control. The Charactron shaped beam tube permits rapid changes of displays, even beyond the limit of human perception.—*General Dynamics/Electronics, Information Technology Div.*, 1895 *Hancock St., San Diego* 12, *Calif.*

CIRCLE 222 ON READER-SERVICE CARD



COMPLETE CLEAN ROOMS

• DESIGNED • INSTALLED
• ONE PACKAGE • ONE PRICE

When you need super clean facilities for manufacturing, assembling or testing, investigate CE "Complete Clean Rooms" before you undertake to act as your own designer, engineer and general contractor.

The total cost of a CE installation is almost always less; you get assured performance to fit your specifications; you start operation on a fixed schedule; and you save executive and engineering time by dealing with one supplier.

Write for bulletin "Complete Clean Rooms" which outlines the scope of CE service and includes thirty-one constructional and operational details of a typical CE Clean Room.

Controlled Environment, Inc.
915 GREAT PLAIN AVENUE, NEEDHAM 92, MASSACHUSETTS

CIRCLE 79 ON READER-SERVICE CARD

SEMICONDUCTOR BASES

Sub-Assembled ready-to-weld copper semiconductor bases—with integral steel rings already brazed in place—are available in standardized 7/16", 9/16" and 11/16" base sizes, each accommodating a variety of sizes and types of caps.—*Standard Pressed Steel Co., Box* 1282, *Jenkintown, Pa.*

CIRCLE 223 ON READER-SERVICE CARD

COOLANT PUMP

New coolant pumping system Type 6449 provides thermally-controlled FC-75 for maintaining differential of 135 psi with flow of 7 GPM. Temperature of coolant is kept at 41°F ±5°F. —*J. C. Carter Co.,* 671 *W.* 17*th St., Costa Mesa, Calif.*

CIRCLE 224 ON READER-SERVICE CARD

VOLTAGE REGULATOR

New S tabiline automatic voltage regulators, Type IE5101MR, for nominal 120 v operation 60 cps, up to 1 kva, ±5%. Also available for 400 cps. Regulation within 0.6v for line variations between 105 and 135, load current from 0 to 8.3 amp and load PF from 0.7 lagging to 1.0, singly or simultaneously.—*The Superior Electric Co., Bristol, Conn.*

CIRCLE 225 ON READER-SERVICE CARD

PHASE COMPARATOR

New LPN-400 voltage and phase comparator using built-in CRT and voltmeter measures in-phase and quadrature voltage components, harmonic content and noise in AC signals over the range of 25 cps to 10 kc.—*Autonetics, Division of North American Aviation, Inc.,* 9150 *E. Imperial Highway, Downey, Calif.*

CIRCLE 226 ON READER-SERVICE CARD

New FAX System is Transistorized

SOLID STATE Facsimile Scan-A-Fax Transmitter (left) accepts letter-width copy, skips non-essential copy at direction of operator. Recorder (right) has quick "pop up" of copy when transmission at recording speed is completed.

A new Facimile communications system, called Scan-A-Fax, is completely transistorized, even down to the frequency standard and motor drive amplifier. This eliminates one of the major disadvantages of present vacuum-tube facsimile systems in that little or no heat is generated. Thus twenty-four hour, day-in day-out operation without electronic malfunctioning is achieved. The system is a product of the Industrial Products Div. of the Fairchild Camera and Inst. Corp., 580 Midland Ave., Yonkers, N. Y.

The Scan-A-Fax scanner-transmitter accepts all types of copy, handwritten or printed, as well as charts and photographs. A new flat-bed scanning system permits transmission of this copy in any width up to 8½" in an almost unlimited length.

A "Rapid Index" feature of the scanner-transmitter unit allows the operator to selectively scan any portion of a letter, chart, log or graph—skipping unnecessary data.

The Scan-A-Flex recorder provides a higher degree of resolution than was heretofore possible on comparable facsimile equipment, easily resolving small typewriter faces, fine grid and map lines and recording up to nine tones of a photographic grey scale. It records at a rate of 15.3 sq-in/min over long-distance telephone lines and at 30.6 sq-in/min over microwave channels. The higher speed is also attainable over short distance telephone lines.

The use of transistorized, printed circuitry permits a compact, lighter system than is attainable with conventional electronic systems. The Scan-A-Fax will be sold direct by Fairchild and also marketed under a lease plan which provides preventive maintenance and periodic updating of equipment.

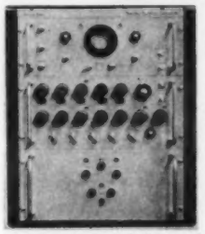
FOR MORE INFORMATION CIRCLE 227 ON READER-SERVICE CARD

4PDT MINI RELAY

New Type H 4PDT, 10 amp relay with balanced rotary type armature meets requirements of MIL-R-25018, -5757D and -6106. Incorporates rectifiers to operate on ac where required. Also new DPDT crystal case relay (not shown) with torsion wire suspension for dry circuit to 2 amp resistive 28v dc rating. —*Union Switch & Signal Div., of Westinghouse Air Brake Co., Pittsburg* 18, *Pa.*

CIRCLE 228 ON READER-SERVICE CARD

TRANSFER FUNCTION COMPUTER



New SA100 Transfer Function Computer measures differential equation coefficients of servo system under test. Transfer functions having terms in the numerator and denominator up to and including fourth order and sixth-order respectively are measured. The SA 100 also a source of low-frequency signals from 0.01 c/s to 5 kc/with Sine, square or triangular wave shapes.—*Wayne Kerr Corp.,* 1633 *Race St., Philadelphia* 3, *Pa.*

CIRCLE 229 ON READER-SERVICE CARD

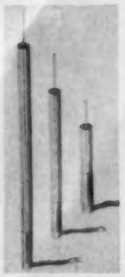
LATCHING RELAY

New "Microlatch" Series of DPDT sealed microminiature latching relays have four coil leads for energizing the operate and reset coil; coils can be wired in series to provide a polarity-sensitive relay. Operates in 6 msec pulse, holds in either position under vibration of 20 G to 2000 cps and shock of 50 G (for 11 msec).—*Filtors, Inc., Port Washington, N. Y.*

CIRCLE 230 ON READER-SERVICE CARD

WESCON Previews—

DIFFERENTIAL TRANSFORMERS



New linear voltage differential transformers—26 v, 400 cps units offered in a variety of sizes and shaft lengths—representing Helipot research and development in the motion transducer field, and presage new translatory velocity transducers.—*Helipot Div. of Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.*

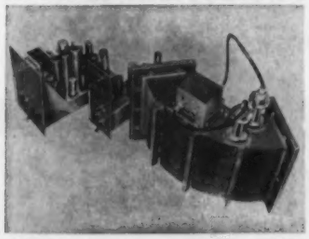
CIRCLE 231 ON READER-SERVICE CARD

COAXIAL SWITCHES

New MA-3464 series of high-speed, all-solid-state switches are available in SPST and multiple pole, multiple-throw configurations. Operate at frequencies ranging from 150 mc to 4700 mc (UHF to C band) from 10 to 100 millivolts during power.—*Microwave Associates, Inc., Burlington, Mass.*

CIRCLE 232 ON READER-SERVICE CARD

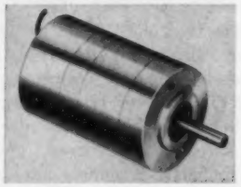
WAVEGUIDE ARC DETECTOR



New L band waveguide arc detector, Model S61-1, is final amplifier protective device on high power radar systems. Photo diodes, mounted external to the waveguide are light activated through optical prisms sealed directly in the waveguide to monitor the windows of the final amplifiers. At the presence of an arc, the signal from the photo diodes is sent through an amplifier section for power to activate a ferrite waveguide switch or to cut off the RF drive to final amplifier. Reaction time of this system from start of arc to cut-off of pulse is 5 to 10 μsec max.—*FXR, Inc., Special Products of the Microwave Div., 25-26 50th St., Woodside 77, N. J.*

CIRCLE 233 ON READER-SERVICE CARD

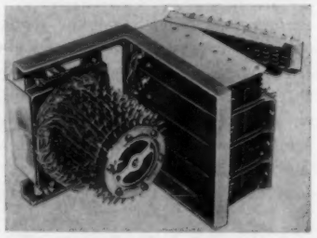
SMALL PM MOTOR



New Model HYLM permanent magnet DC motor is the smallest Mil-Spec Barber-Colman sub-fractional horsepower motor. Only 1" dia, the motor features precision ball bearings, constant pressure brush springs and explosion proof housing.—*Barber-Colman, Dept. 2411, Motors and Components Div., Rockford, Ill.*

CIRCLE 234 ON READER-SERVICE CARD

ROTARY STEPPING SWITCH



New Stepping Switch providing 240 individual connections for access to control, selection, sequencing or pulsing circuits is available completely wired to plug-in connectors.—*North Electric Co., Electronics Div., Galion, Ohio.*

CIRCLE 235 ON READER-SERVICE CARD

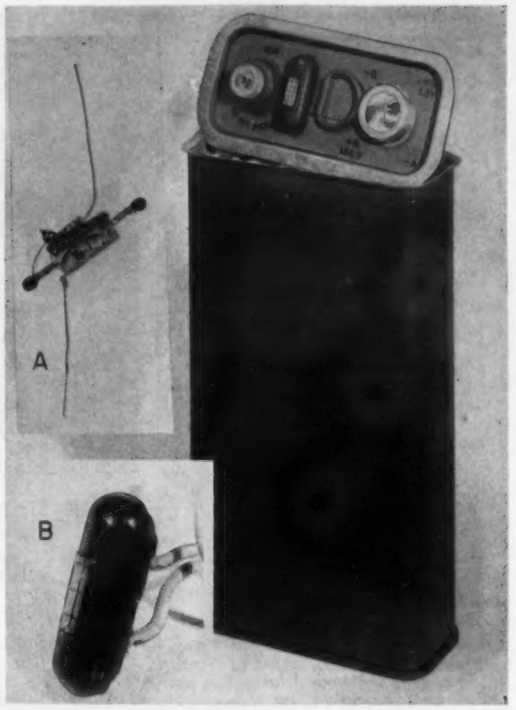


FIG. 1. UNUSED CAPACITY of Mercury battery is indicated by new ampere-hour indicator. Inset(A) shows meter tube and associated ballast and shunt resistors before encapsulation; (B) shows enlarged view of meter after encapsulation.

Miniature Battery-Power Meter

SUCCESS of a military scouting mission—or the lives of survivors on a raft at sea—can depend on the amount of unused power remaining in a mercury battery. Heretofore this often has been the "X" quantity in the equation. Now a new miniature ampere-hour indicator, designed to use with the Mallory BA/1315/U mercury battery in military survival transceiver application, answers this question at a glance (Fig. 1).

The new meter, only ¾" long, a development of Curtis Instruments, Inc., Mount Kisco, N. Y., consists of a capillary tube filled with mercury, with the mercury column separated into two sections by a liquid electrolyte gap. This gap, the indicator, moves along the length of the tube as a function of the amount of current passing through the meter. The mercury is transferred from one side of the gap to the other by an electroplating process.

The battery capacity indicator is constructed using a ¾" long Curtis meter on which is cast a lens and scale from water-clear epoxy manufactured by Epoxy Products Inc. A shunt and ballast resistor are then fastened to the meter, and the scale and resistors are encapsulated in a cast epoxy housing.

TELEPHONE PICKUP

New Hum-Bucking Telephone Pick-up Coil designed for use with high impedance input recorders and dictating machines when transcribing telephone conversations cancels stray hum pickup.—*Microtran Company, Inc.*, 145 *East Mineola Ave., Valley Stream, N. Y.*

CIRCLE 236 ON READER-SERVICE CARD

PLUG-IN POLY-DIODE

New Poly-Diode consisting of up to five separate diode junctions, each with an individual lead, formed on a single silicon slice in a computer gate configuration.—*Delta Semiconductors*, 835 *Production Place, Newport Beach, Calif.*

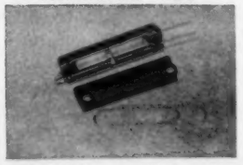
CIRCLE 237 ON READER-SERVICE CARD

FM SIGNAL GENERATOR

New Model 1001 Signal Generator is continuously tunable through the 100-550 mc range with drift of less than .015% per hr. FM deviation is controllable in two ranges, 0-35 kc and 0-350 kc, and output voltage is 0.25 μv to 100,000 μv into 50 ohms.—*R S Electronics Corporation, P. O. Box* 11365, *Station A, Palo Alto, Calif.*

CIRCLE 238 ON READER-SERVICE CARD

TRIMMING POT



Models in the new film series have the same physical dimensions as present Atohm wirewound potentiometers, Model 110, 120, 210, 220, and 320.—*Atohm Electronics*, 7648 *San Fernando Road, Sun Valley, Calif.*

CIRCLE 239 ON READER-SERVICE CA

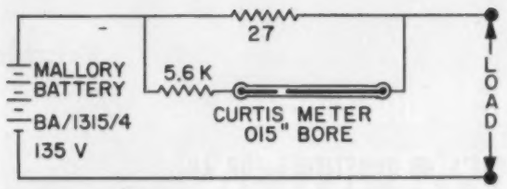


Fig. 2. BATTERY METER Schematic diagram. In this application, battery is not recharged but discarded when exhausted. On rechargeable types, meter would indicate need for, or extent of recharge.

The battery for which the unit has been designed is used in conjunction with a military survival transceiver. This set operates with different drains on the battery in its receive and transmit mode, providing an impedance of 2,980 ohms when transmitting and 10,400 ohms when receiving.

Mallory desired to provide an indication of battery capacity available to the operator of the transceiver; enabling him to gauge the amount of power left in the battery would permit him to more judiciously operate the set.

The capacity indicator has an active scale approx. ¼" long with four divisions, which indicates the percentage of power left in the battery by the position of the gap in the mercury column. The unit uses a 27-ohm shunt resistor in series with the load terminals and a ballast resistor of 5600 ohms in series with the meter. The indicator gap will move its full scale (.235") with the complete discharge of the battery (500 ma-hrs.).

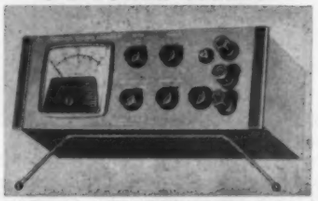
The Curtis meter has been tested against military vibration and shock specifications and has successfully passed vibration of 20 G at 2000 cps and shocks up to 70 G. It will operate through an ambient range of −38° to 110°C; withstands storage temperatures from −65° to 125°.

In the Mallory application, the value of shunt resistance (27 ohms) was chosen as an optimum value providing sufficient voltage to permit an adequate indication (.250") of battery capacity and yet use less than 1.0% of the battery capacity when transmitting, and less than 0.20% of the battery power when receiving. The installation of the battery is made such that failure of the meter will not in any way interrupt the supply of current to the transceiver (Fig. 2).

Although the Curtis ampere-hour meter is reversible, dependent upon the polarity of the connections to the meter, this feature of the meter is not being utilized in the Mallory application since the mercury cells are not rechargable and the battery is disposed of upon use.

FOR MORE INFORMATION CIRCLE 244 ON READER-SERVICE CARD

T-D POWER SOURCE



New Model TD6M Tunnel Diode Power Source provides highly stable voltage and current biases in the 0-6Vdc and millivolt region. Current rating is 0-100 ma. Regulation corresponds to 0.05% vac, 60-400 cps and 0-100% load change.—*Electronic Research Associates, Inc.*, 67 *Factory Pl., Cedar Grove, N. J.*

CIRCLE 240 ON READER-SERVICE CARD

DIGITAL COUNTERS

New line of high speed, low torque, direct drive counters give plus and minus, right and left, or directional digital readings.—*Veeder-Root Inc.*, 70 *Sargeant St., Hartford* 2, *Conn.*

CIRCLE 241 ON READER-SERVICE CARD

PRIMARY AC SHUNTS

New coaxial, 4-terminal resistor current shunt set designed for a minimum of self-inductance has an accuracy of ac-dc difference for frequencies above 5 cps and below 50 kc to .02%. UHF type connectors provide easy connection.—*Holt Instrument Laboratories, P.O. Box* 230, *Oconto, Wis.*

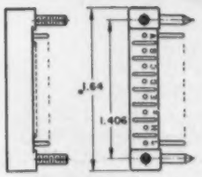
CIRCLE 242 ON READER-SERVICE CARD

DIGITAL CLOCKS

New Model 2000 Series Digital Clocks with 8-4-2-1 binary-coded-decimal outputs parallel with decimal outputs are combined in the same clock with a separately wired common for each decimal digit position to permit easy conversion to serial form, and also actuate visual displays, tape printers, and typewriters without code conversion.—*Chrono-Log Corporation, Box* 4587, *Philadelphia* 31, *Pa.*

CIRCLE 243 ON READER-SERVICE CARD

Right-Angle Printed-Circuit Connectors



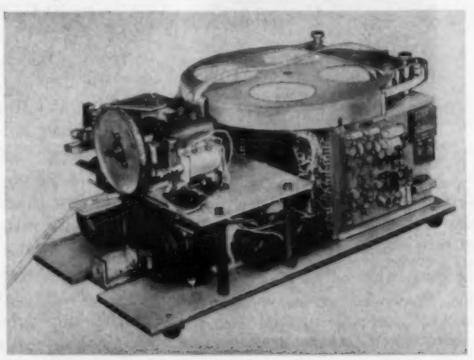
600-70-3 PLUG
8 CONTACTS

Series 600-70 miniature right angle pin and socket connectors are available in 4, 8, 10, 12, 13, 22 and 28 contacts. Guide pins in the plug and guide bushings in the socket provide guided insertion and prevent bending of contacts . . . Precision machined socket contacts are phosphor bronze with gold plate over silver plate. Pin contacts are brass and stainless steel, gold plate over silver plate. All contacts have low contact and corrosion resistance, and are easy to solder . . . (*From* 12-*page Catalog RTA-*1260, *Electronics Div., DeJur-Amsco Corp.,* 45-01 *Northern Blvd., Long Island City* 1, *N. Y.*)

FOR MORE LITERATURE CIRCLE 374 ON READER-SERVICE CARD

Field Data Teleprinter

High-speed Field communications readout equipment for use with mobile field computers is being manufactured by the Kleinschmidt Division of Smith-Corona-Marchant Inc., 410 Park Ave., New York 22, N. Y. The high-speed serial printer, Model 6400,



shown in the figure utilizes solid state logic, translating 8-channel intelligence data into 64 different alphabetical, numerical and special symbols, on 5/16" paper tape.

Because of the high speed employed, no data storage component is required. The field data set, also comprising a teleprinter, reader and punch, can be housed in a truck or trailer along with the associated computer, enabling the combat forces to utilize automation to streamline communications and data-readout on which military strategy and tactics depends.

Important industrial and commercial uses are also forseen for the new equipment.

FOR MORE INFORMATION CIRCLE 245 ON READER-SERVICE CARD

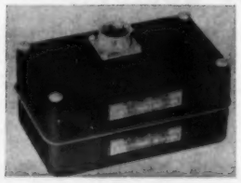
WESCON Previews—

MICRO RELAY

New Series MM-22 Sealed Microminiature DPDT Relay fabricated under "Clean Room" conditions is expected to have a life of ten million operations in dry circuit applications. Minimum contact life is 100,000 operations at 3 amps. Max operate and release times are 5 msec each. The relay functions over a temperature range of −65° to 125°C and under severe vibration and shock.—*Automatic Electric Co., Northlake, Ill.*

CIRCLE 246 ON READER-SERVICE CARD

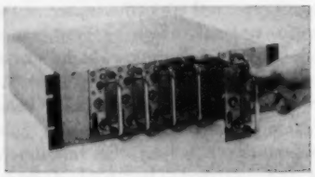
DESTRUCT RECEIVER



New Model 2621/1803 Command-Destruct Receiver/Decoder for missiles is designed to operate in severe missile environments and to meet the interference requirements for Class I equipment. Receiver range is 406-549 mc. Decoder provides a destruct signal when three tones are received in a predetermined combination and sequence.—*R S Electronics Corporation, P. O. Box* 11368, *Station A, Palo Alto, Calif.*

CIRCLE 247 ON READER-SERVICE CARD

TRANSDUCER SIGNAL CONDITIONER



New PS-290 Power Supply and the PB-290 Power and Balance unit incorporate plug-in card circuits for up to eight transducer channels. Bridge completion, balancing, and calibration resistors are easily accessible from the front. Output ripple is less than 500 μv peak-to-peak or 200 μv RMS; and line regulation is less than 0.02%. Isolation is less than 0.01 μamp at 60 cps, and output impedance is less than 0.05 ohm.—*Microdot Inc.,* 220 *Pasadena Ave., South Pasadena, Calif.*

CIRCLE 248 ON READER-SERVICE CARD

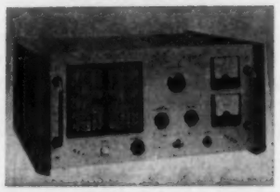
CIRCLE 84 ON READER-SERVICE CARD→

AIRBORNE-PARTICLE SIZE ANALYZER

New Model PC-200A Particle Counter displays the number of particles present in 15 sub-ranges of sizes from 0.32 μ to 8.0 μ diameter. Counts appear visually on decade counters, but can be recorded on digital tape or a strip-chart recorder, or both. At the normal air flowrate of 100 cc/min the count rate without excessive coincidence loss is 7340 particles. If no particles are present, the instrument will not respond.—*Royco Instruments Inc., 440 Olive St., Palo Alto, Calif.*

CIRCLE 249 ON READER-SERVICE CARD

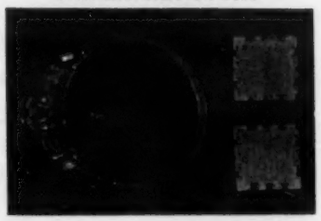
POWER SUPPLY



New Model QCR 36-30 transistorized power supply features a continuously adjustable output of zero to 36 vdc. Precise regulation of $\pm 0.01\%$ + 1 mv and reduced ripple of 0.5 millivolts RMS maximum, results from a new circuit concept.—*William Buck, Sorensen Products, Richards Ave., S. Norwalk, Conn.*

CIRCLE 250 ON READER-SERVICE CARD

WAFER RESISTORS

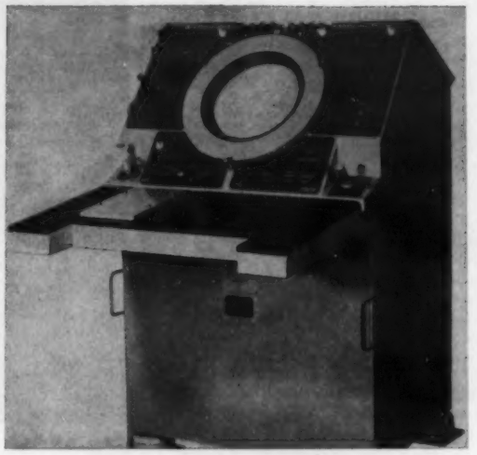


New line of micro-miniature resistors on the standard RCA wafer, for micro-module developments, are made to customer specifications. Dimensions of wafer are .31" x .31" x .010" with 12 interconnecting notches. Electrical specifications are: Resistance range from 100 ohms to 100 K ohms, tolerance $\pm 1\%$, temperature coefficient of 100 PPM/°C and a maximum dissipation ⅛ watt per wafer. As many as four resistive elements can be placed on a single wafer. Sample units available.—*Dale Electronics, Inc., Columbus, Neb.*

CIRCLE 251 ON READER-SERVICE CARD

End of WESCON Previews

More New Products pages 70, 74



Radar Uses Direct Readout Counters

Direct readout counters, replacing dials for instantaneous communication of instrument-derived information, are used on the new AN/SPA-34 Range Azimuth Indicator designed for the Navy by the Communications and Weapons Systems Div., Government and Industrial Group, Philco Corporation.

It employs counters to indicate angular position and range determined by a time-shared electronic cursor sweep, as well as to show north-south and east-west coordinates established by manual off-centering radii.

Video, trigger, and azimuth information from the associated radar are fed into the indicator. The video signals are displayed as range and azimuth information on a 10" PPI cathode-ray tube. Fixed range marks appear on the video display, and a variable range strobe can also appear on the video sweep. Sweep range is continuously variable from 4 to 400 miles.

Individual target bearings can be determined by use of the electronic cursor which is timed-shared with the video sweep. The cursor origin can be off-centered with respect to the video sweep, or the video sweep origin can be off-centered with respect to the cursor, or both origins can be simultaneously off-centered from the center of the cathode-ray tube screen to make bearing and range measurements between any two points, which speeds the accurate solution of air defense problems.

Special Counter Indicates Degrees. Both angle (bearing) and distance (range) polar coordinates are indicated on special counters developed by the Instrument Div. of Veeder-Root Incorporated (Hartford, Conn.). Angle of cursor bearing is actually read out in degrees, from 0° to 359°, to establish the angle of the target in comparison with the direction of the ship.

To avoid space-consuming extra-large wheels in the "degrees counter," Veeder-Root uses a unique counter design which selectively displays the tens-of-degrees numerals through apertures in a cylindrical shutter. Thirty-five sets of figures are thus contained on a wheel diameter equal to a normal ten-figure indicator.

Range coordinate is read out on an unusual "miles and yards" counter which consists of three lateral sections.

The right-hand section indicates yards (in 200 yard increments), and the center section miles and tenths. For every two hundred yards indicated, the miles counter advances one-tenth. At forty miles (80,000 yards) the yards section automatically closes the middle section with a shutter, and opens a shutter on the left-hand section, which counts in full miles as high as the radar equipment can sense.

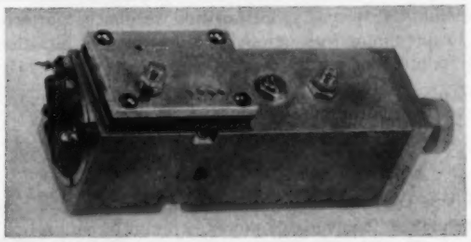
When used as general purpose PPI (Plan Position Indicator), the entire display, including cursor, can be offset by means of manual east-west and north-south off-centering controls and/or or automatically by means of the ship's DRA (Dear Reckoning Analysis) inputs. Dual counters show the sum of the east-west and north-south cartesian coordinates.

For example, if a target is located in the north-east quadrant of the video display, the dual counters for "North" and "East" are revealed. The following information is indicated: the North counter shows how many miles north the target is located, and the East counter shows number of miles to the east of true North.

FOR MORE INFORMATION ON DIGITAL COUNTERS CIRCLE 252
FOR MORE INFORMATION ON RADAR INDICATOR CIRCLE 253

Miniaturized Coax Cavity Modules

The "building block" technique is extended into the microwave coaxial cavity field in a wide variety of Microdot miniaturized modules. Careful design has made many parts common, which are carried in stock. Thus prototype units having unusual specifications can often be



assembled in extremely short time.

Basic Microdot design has yielded oscillators, amplifiers and frequency multipliers, each tailored to its specific requirements. Shared in common are features of small size and light weight, rugged construction, and the ability to withstand severe environments.

A typical power amplifier is the Model 227, (See Figure) 960mc amplifier having up to 25 watts output, which was designed to form part of a high-power amplifier chain where the primary requirement was long life and day after day of dependable, unattended service. The miniature construction of these units and their performance under severe environments make them attractive to designers looking for maximum performance in small space. High overall efficiency (50% including filament power) provides an added bonus—not only is less heat generated, but there is a space and weight saving in the reduced requirements for primary power. (*From 4-page brochure, "Airborne VHF-UHF Transmitter and Cavities," Microdot, Inc., 220 Pasadena Ave., South Pasadena, Calif.*)

FOR THIS LITERATURE CIRCLE 254 ON READER-SERVICE CARD

Top Two Together

Complete Line Now Available

Air Marine Motors of Amityville, New York and Motordyne of Los Angeles, California have combined to offer industry an extensive line of both AC and DC motors in the fractional horsepower range. Motors from these companies have for years fulfilled the requirements of both industry and military. The wide variety of types offered makes this source invaluable to the design engineer. Comprehensive literature on units to fulfill specific needs is available from either the east or west coast facilities.

Quality is a Statistic

Motors from Air Marine and Motordyne have gained a reputation of reliability based on the quality of performance. Numerous units designed for the military have continually met rigid environmental requirements. Hundreds of pages of statistics are available to establish beyond any doubt the ability of these motors to meet all types of specifications.

Research and Development

Laboratories are maintained on both the east and west coasts, under the direction of highly competent engineers who continually probe for more advance techniques in the manufacturing of rotating components. The AC and DC motors of these corporations are continually being studied to increase their life and efficiency. These laboratories also study specific problems of customers relative to motor performance.

Engineering Consultation

The field engineers of Air Marine and Motordyne are trained to assist the customer in the selection and installation of motors. These engineers are often called upon by the customer to assist in specifying the right motor for a specific job. A call to either the east or west coast facility will alert these engineers to your specific problems.

Additional Lines from Air Marine and Motordyne

Now from these extensive facilities a complete line of blowers, fans, governors, brakes, gears, servo motors and thermal overload switches have become available: Complete information is available on request.

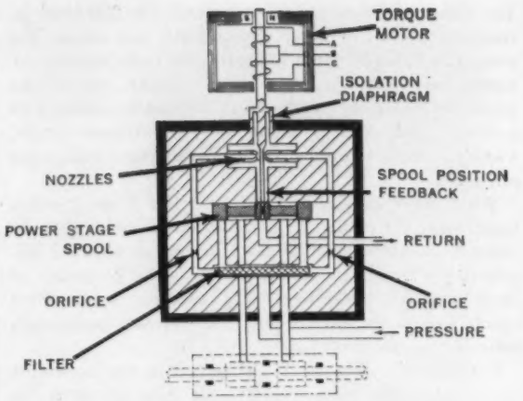


FIG. 1. FLOW CONTROL by Model 25 Transducer is triggered by dry stage torque motor, amplified by hydraulic power stage to drive separate actuator.

Miniature Flow Control Transducer

The Hydraulic Research Model 25 miniature flow control transducer, although only 1½" in overall height and weighing 5 ounces, is designed for precision use in any high performance control system that operates within 1.3 GPM flow at 3000 PSI drop across the valve. Its efficient design includes the use of unique spool position feedback, powerful dry torque spool position feedback, powerful dry torque motor with parallel magnets, central filtration, and stainless steel construction throughout (Fig. 1).

Steady state characteristics: The steady state equation relating input current (i) to output from (q) with the load relationship (P_L) is given by

$$q = Ki(P_s - P_L)\ ½$$

Where P_s is the supply pressure and K is a constant. The equation for available power is found by multiplying the equation for flow by P_L. Then differentiating the equation for power and maximizing gives

$$P_L = \frac{2}{3} P_s.$$

Therefore, with a constant input of current, the maximum power available occurs when the load is two-thirds of the supply pressure.

Dynamic characteristics: The transfer function for operation of the operation of the transducer below 50 cps can be approximated as a first order lag. (See Fig. 2). The transfer function is

$$q/i\ (s) = \frac{Kv}{\tau s + 1}$$

Where:

Kv = Static gain (GPM/ma)

s = Laplace operator

τ = Time constant (sec.)

Kv will vary with load as shown by the steady state equation for flow. The time constant (τ) is approximated by the frequency at which 45 is approximated by the fre-

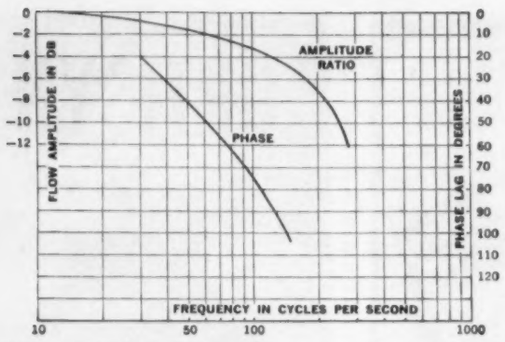


FIG. 2. TYPICAL DYNAMIC Response Characteristics, Model 25 Miniature Flow Control Transducer.

quency at which 45 degrees phase lag occurs and is approximately

$$\tau \cong .0025 \text{ sec.}$$

For operation of the transducer above 50 cps, an approximation of its transfer funtion is

$$q/i\ (s) = \frac{Kv}{\frac{S^2}{\omega_N{}^2} + \frac{2\zeta}{\omega_N} S + 1}$$

Where:

ω_N = Natural frequency (radians/second)
ζ = Apparent damping ratio

ω_N is determined by the frequency at which 90 degrees phase lag occurs. ζ is determined by the response amplitude at ω_N. Useful approximations are:

$$\omega_N \cong 750 \text{ radians/sec.}$$

$$\zeta \cong 0.8$$

(*From 4-page brochure, Hydraulic Research & Mfg. Co., 2835 N. Naomi St., Burbank, Calif.*)

FOR THIS LITERATURE CIRCLE 255 ON READER-SERVICE CARD

Cable and Tubing Products

Eight new product lines are featured by Alpha Wire in their latest catalog No. 62, which details more than 6000 electronic wire cable and tubing stock products.

ZIPPER Tubing of polyvinyl chloride resists cold embrittlement down to 76°C or is bonded to fibreglass for temperatures to 130°C. Diameters from 1/4" to 4" and with zipper portion in eleven different colors are available. Foil shielding can also be provided.

The new product lines include Heat Shrinkable Tubing, Retractile coil power and communication cords, High Temperature (260°C) Teflon tubing, Zipper Tubing (see Figure), Mil-Spec QQ-B-575 shielding and braiding, shielded teflon cables, teflon magnet wire and shielded audio cables.

(*The new 52-page catalog is available on request from Alpha Wire Corporation, 200 Varick St., New York 14, N. Y.*)

FOR THIS LITERATURE CIRCLE 256 ON READER-SERVICE CARD

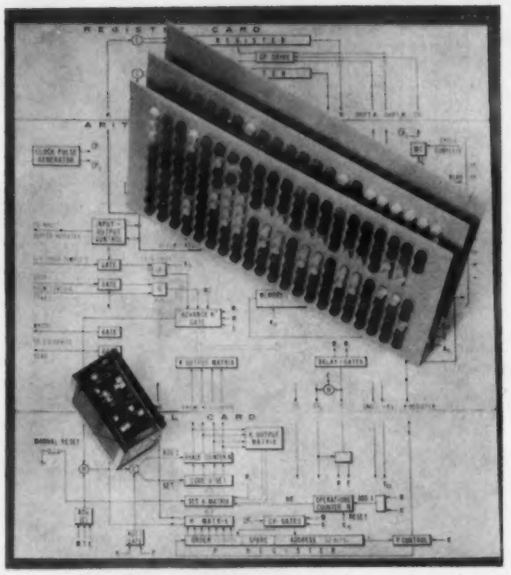


FIG. 1. COMPLETE LOGIC sections for a general purpose digital computer are shown in mock-up form using Micrologic elements in (1) TO-5 size packages mounted on 6" x 12" circuit boards and (2) TO-18 size packages using welded wire interconnections (lower left). The best equivalent logic section using conventional high-density packaging would require 40 of the 6" x 12" printed circuit boards shown in the upper right.

Micrologic Devices

Micrologic Flip-flop, Gate and Half-shift Register, the first three of a new family of integrated microminiature semiconductor devices designed to lead to major reductions in the size and cost of solid-state digital computers, will be exhibited by Fairchild Semiconductor, Mountain View, California, at Booth 814-816 during the 1961 WESCON show.

Three additional devices are undergoing final development—Micrologic buffer, half-adder, and counter adapter —and will be available as products by the end of 1961.

A complete logic section of a digital computer can be fabricated using the three Micrologic elements currently available. A 20 per cent reduction in the number of devices necessary for fabrication will be possible when the Micrologic buffer, half-adder and counter adapter become available later this year.

Using direct-coupled transistor logic (DCTL), and silicon Planar techniques, the Micrologic elements are made by diffusing the transistors and resistors for many units into a single slab of silicon. The metallic interconnections are deposited on top of the slab which is then cut into the individual Micrologic elements. These elements are then mounted in a standard JEDEC TO-5 (for Standard Printed Circuit Boards) or TO-18 (for Welded-wire Circuit Packages) as shown in Fig. 1.

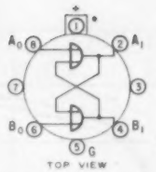
Specification forms, such as those for the Micrologic flip-flop and half-shift register elements shown in Fig. 2, describe those characteristics which are of interest to the logical engineer. Not only is he guaranteed that each device will operate individually, but he is also assured

PRELIMINARY CHARACTERISTICS

MICROLOGIC ELEMENT "F"
FLIP - FLOP

SUPPLY VOLTAGE + 3 V_{dc} ± 30%
POWER DISSIPATION 30 mW (TYP)
TEMPERATURE -55°C TO +125°C

$\bar{A}_1 = B_1 + A_0$
$\bar{B}_1 = A_1 + B_0$



INPUT (TERMINALS 6,8) - CAN BE DRIVEN BY ANY MICROLOGIC ELEMENT - 1 MICROLOGIC LOAD.

OUTPUT (TERMINALS 2,4) - CAN DRIVE UP TO 4 OTHER MICROLOGIC ELEMENT LOADS IN PARALLEL.

AVERAGE DELAY - 50 nsec.

PRELIMINARY CHARACTERISTICS

MICROLOGIC ELEMENT "S"
HALF SHIFT REGISTER

SUPPLY VOLTAGE + 3 V_{dc} ± 30%
POWER DISSIPATION 60 mW (TYP)
TEMPERATURE -55°C TO +125°C

$\bar{A}_1 = B_1 + \bar{A}_0 \bar{P}$
$\bar{B}_1 = A_1 + \bar{B}_0 \bar{P}$

INPUT - CAN BE DRIVEN BY ANY MICROLOGIC ELEMENT.
A_0, B_0 (TERMINALS 6,8) - 1 MICROLOGIC LOAD.
P (TERMINAL 7) - 2 MICROLOGIC LOADS.

OUTPUT (TERMINALS 2,4) - CAN DRIVE UP TO 4 OTHER MICROLOGIC ELEMENT LOADS IN PARALLEL.

AVERAGE DELAY - 100 nsec.

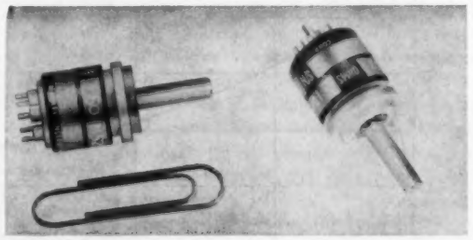
FIG. 2. MICROLOGIC Typical Element Specifications. Assignment of pin terminals facilitates printed circuit design.

that the device will function compatibly when interconnected with other elements in a system. Careful planning of pin assignments for the various inputs and outputs permits straight-through wiring and reduces the incidence of cross-over.

FOR MORE INFORMATION CIRCLE 257 ON READER-SERVICE CARD

Size 5 Precision Servo Pot

New wirewound potentiometer designed for high-reliability applications in missile, aircraft or ground support equipment and used with Size 5 (½" dia) servos is available with resistance ranges of 50 to



100,000 ohms. Linearity is ±0.75% for resistances less than 10K, ±0.50% for 10K and above. Wattage is 2 watts at 80°C derating to zero at 125°C. Meets environmental specs NAS710, MIL-R-19A, - 27208, - 12934B and MIL-E-5272A with operating temperatures from 50° to 125°C. Electrical function angles from 30° to 354° are available, and bronze sleeve bearings, ball bearings or sealed construction may be specified by customer. Shaft rotational torque is .05 oz-in with bronze bearings . . . (*From 50-page catalog, "Single-Turn Precision Wire-Wound Potentiometers," Maurey Instrument Corporation, 7924 South Exchange Ave., Chicago 17, Ill.*)

FOR THIS LITERATURE CIRCLE 258 ON READER-SERVICE CARD

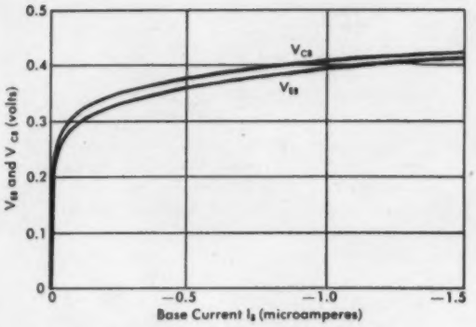


FIG. 1. V_{cb} and V_{eb} Base Current.

Transistor Chopper Transients

The switching action of a transistor used in low level choppers introduces voltage transients in the output. At chopping frequencies, the transients are produced by capacitive feedthrough of the drive signal to the output through junction capacitances and by the transistor switching time. The unequal turn-on characteristics of transistor junctions generate voltage peaks in low-frequency choppers. All output voltage transients can be reduced if not completely eliminated by correct chopper transistor circuit design.

One type of output voltage spike predominant at low frequencies (to about 200-300 cps) is the offset voltage transient caused by the unequal dc turn-on characteristics of the transistor junction and the interaction between them. Fig. 1 shows both the emitter-base and collector base voltages as a function of base current. The offset voltage, or potential difference between the emitter and collector terminals, reaches a peak at a base current of about 0.3 μamp (Fig. 2), but decreases as V_{cb} and V_{ce} approach each other with increasing base current. The effect on output voltage compared with base drive voltage

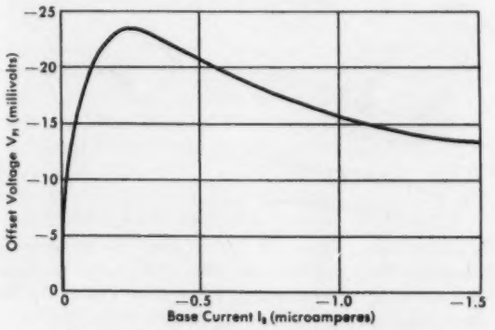


FIG. 2. **OFFSET** Voltage vs Base Current.

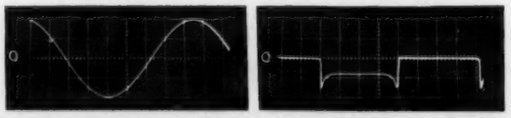


FIG. 3. **OFFSET VOLTAGE** Transient (left) Base Drive, vert. 2v/div: (right) Output voltage, vert. 1 mv/div. Horizontal scales both 2 μsec/div.

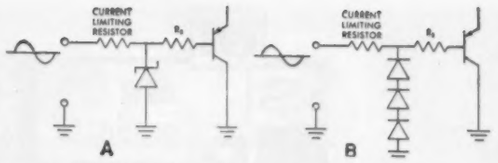


FIG. 4. DRIVE CIRCUITS for transistor choppers using sinewave inputs. (A) Zener diode clamping. (B) Stabistor clamping (preferred for low-level applications).

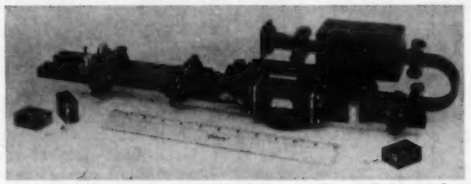
is seen in Fig. 3.

The effects of the offset voltage spike can be minimized by increasing the rise time of the base drive voltage. This is done by increasing the drive voltage while providing zener or stabistor clamping of the input (Fig. 4). —(*From Technical Applications Bulletin No.* 2109, *"Transients in Transistor Choppers," Sperry Semiconductor Division, Sperry Rand Corporation, Norwalk, Conn.*)

FOR THIS LITERATURE CIRCLE 259 ON READER-SERVICE CARD

Solid-State Limiter Replaces X-Band TR Radar Tubes

Nonlinear properties of both ferrites and diodes are exploited in a new ferrite-diode power limiter designed to protect radar mixer crystals. According to Dr. Howard T. Ozaki, manager of the Hughes Aerospace R & D Division, Hughes Aircraft Co., Culver City Calif., a Navy-



sponsored effort has developed an all-solid-state device featuring completely passive operation, instantaneous recovery time, long life and excellent reliability and protection at high power levels. In contrast, conventional TR tubes have the disadvantage of long recovery time, limited life and uncertain reliability.

Former attempts to apply the non-linear properties of ferrites in X-band limiters were not satisfactory because of a large leakage spike on the limiter output pulse. Combination of the ferrite limiter with a suitable varactor diode limiter reduces the leakage spike to a very low level. Tests on the first experimental model show that the limiter delivers an output power low enough to protect the mixer crystal from incident power up to 5 kilowatts.

Ferrites show no attenuaton at low power levels but protect against high power levels by absorbing power to excite subharmonic spin waves in a type of parametric oscillator. Because of the time required to excite the spin waves a large leading spike of about 0.1 μsec duration is present. Properly biased varactor diodes placed in the microwave circuit also have low loss at low power levels but at powers above 500 mw produce a reactive affect which absorbs the leakage spike, thus supplying an output pulse below the crystal burnout level. The complete limiter, employing diode and ferrite protection, is shown in the illustration.

FOR MORE INFORMATION CIRCLE 260 ON READER-SERVICE CARD

MSD new products

LOWPASS FILTER

New Model 280 UHF Harmonic Filter eliminates harmonics of 215 - 260 mc telemetry transmitters, while serving as the RF output fitting for a pressure-tight transmitter. Insertion loss, less than 0.5 db below 260 mc, 50 db above 450 mc.—*Adams-Russel Co., Inc., 200 Sixth St., Cambridge 42, Mass.*

CIRCLE 261 ON READER-SERVICE CARD

SPACE TRANSMITTER

The first ultra high power, high frequency transmitter designed to operate efficiently in the actual flight environment of missiles and spacecraft provides an output power of 1 to 2 kw at a frequency of 200 to 400 mc, in a cylinder 4½" dia. x 13" long.—*Space Electronics Corp., 930 Air Way, Glendale, Calif.*

CIRCLE 262 ON READER-SERVICE CARD

TANTALUM CAPACITOR

New HV Type axial lead-type tantalum foil capacitors have single-unit ratings to 300 wvdc, over the temperature range −55° to +85°C, and to 250 wvdc from −55° to +125°C. —*Tansitor Electronics, Inc., West Road, Bennington, Vt.*

CIRCLE 263 ON READER-SERVICE CARD

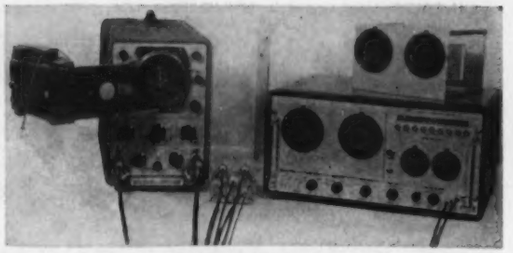


FIG. 1. SMITH CHART Coupler (center of picture) is being used with Swept Signal Generator (right) to obtain an accurate Smith Chart plot on the oscilloscope. A Polaroid camera mount is provided for quick data recording, which can be checked on the spot.

Smith Chart Impedance Plotter

The measurement of complex impendances over a band of frequencies has historically been accomplished by the use of slotted lines—a technique requiring highly skilled technicians. In comparison with this method, the Smith Chart Plotter is quick, simple and most versatile. Designed and developed by the Dielectric Products Engineering Co., Inc., it provides impedance and admittance measurements of such diverse components as antennas, filters, load resistors, transformers and other RF networks.

The Dielectric Smith Chart Coupler provides two push-pull outputs, one which is proportional to $\rho\sin\theta$ for horizontal deflection of the oscilloscope beam, the other which is proportional to $\rho\cos\theta$ for vertical deflection. As used here, ρ is the magnitude of the reflection coefficient, and θ is its phase angle with respect to the incident wave.

The latest equipment (Fig. 1) consists of the Telonic MS2000 Swept Signal Generator, with plug-in heads to match the tuning ranges of the Smith Chart Plotters, the Dielectric Smith Chart Coupler, and the oscilloscope equipped with a camera mount to accommodate any Polaroid camera using the Land 3000-speed film. A load resistor is being measured in this picture.

Calibration of the coupler is shown in the pictorial diagram, Fig. 2. A known mismatch at the end of a delay cable is substituted for the device under test. For example, a 600 ohm load is appropriate when the expanded chart faceplate is to be used. In this case, the VSWR would be 1.2 since $Z_0 = 50$ ohms.

With the signal generator sweeping, the signal level, the oscilloscope X and Y gains, and the X and Y adjustments on the coupler are adjusted to make the trace coincide with the 1.2 VSWR circle on the Smith chart.

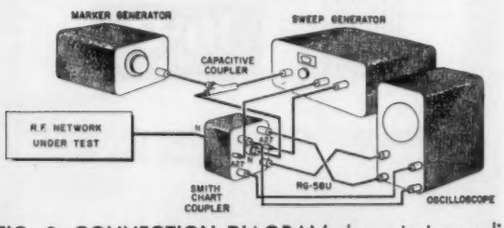


FIG. 2. CONNECTION DIAGRAM shows test or calibration method.

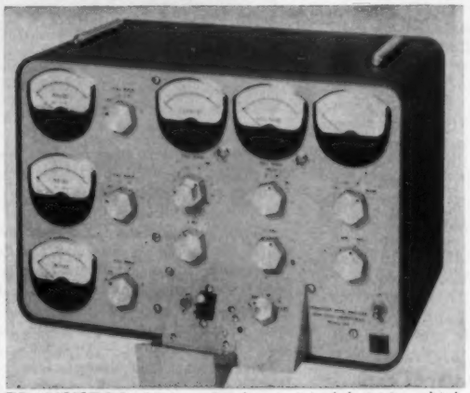
While making these adjustments, the X and Y positioning controls of the Hewlett-Packard oscilloscope are used to center the blanking dot on the Smith chart.

To properly orient the resistance axis of the faceplate, the mismatch is removed and the unknown load or component is connected. At the required impedance reference point, which for example might be mounted to an antenna or filter, the feed line is shorted and the signal generator adjusted to the center frequency of the band to be swept. The R-axis of the faceplate is rotated to align with the blanking trace. At this point, the plotter is completely calibrated and ready for use.—(*From bulletin* 60-3, *Dielectric Products Engineering Co., Inc., Raymond, Maine.*)

FOR THIS LITERATURE CIRCLE 268 ON READER-SERVICE CARD

Component Noise Clinic is WESCON Attraction

On-the-spot tests of sample batches of resistors, capacitors, transistors and diodes for excessive noise will be performed without charge by component-noise experts from Quan-Tech Laboratories, Boonton, N. J. at their WESCON booth 1020-1021. Firms or individuals are invited to bring in samples for analysis; detailed reports



TRANSISTOR Noise Analyzer Model 310, which simultaneously measures noise inherent in transistors at 100, 1000 and 10,000 cps, will be used in the WESCON Noise Clinic. The low frequency bandpasses indicate fluctuation noise, while the higher range measures "shot" noise.

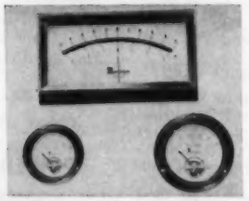
of the amount of noise generated by the components will be provided immediately.

Analyses of noise will be accomplished by equipment developed and manufactured by Quan-Tech, including the Model 310 Transistor Noise Analyzer, Model 314 Diode Noise Analyzer, Model 315 Resistor Noise Test Set, Model 303 Noise and Wave Spectrum Analyzer and other accessory noise equipment.

According to Quan-Tech engineers, component noise as a major problem in electronic technology is receiving increased attention because of the Armed Forces' insistence on increased reliability. In addition to the degrading effects of noise upon performance, there is increasing evidence that a correlation may exist between noise and reliability. The only safeguard is 100% inspection of critical components for high noise levels. Quan-Tech equipment enables such production tests.

FOR MORE INFORMATION CIRCLE 269 ON READER-SERVICE CARD

PANEL METERS



New Model 145 commercial panel meter achieves a scale length of over 4" in a meter measuring only 2¾" by 5". Models 25 and 35 meet all provisions of MIL-M-10304B.—*Rowan Controller Co., 30 Bridge Ave., Red Bank, N. J.*

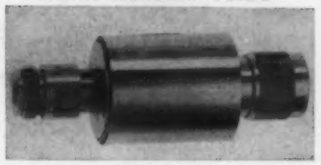
CIRCLE 266 ON READER-SERVICE CARD

RESISTOR NETWORKS

New lug-type resistor networks $\frac{5}{16}$" diameter, are available in lengths up to 6" with a maximum of 13 resistors in the network.—*Reon Resistor Corporation, 155 Saw Mill River Rd., Yonkers, N. Y.*

CIRCLE 267 ON READER-SERVICE CARD

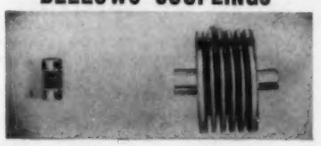
COAX ROTARY JOINT



New Model 320 Coaxial Rotary Joint for antenna-receiver and servo-drive applications from 800 - 12000 mc has VSWR of 1.10 at 800 - 6000 mc, to 1.30 at 8000 - 12000 mc.—*Sage Laboratories, Inc., 3 Huron Drive, East Natick Industrial Park, Natick, Mass.*

CIRCLE 270 ON READER-SERVICE CARD

BELLOWS COUPLINGS



Sub-miniature to medium size hi-flex couplings are applicable to servomechanisms and computers where backlash and cylic angular variations between 2 shafts cannot be tolerated.—*Sterling Precision Corp., 17 Matinecock Ave., Port Washington, L. I., N. Y.*

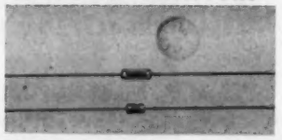
CIRCLE 271 ON READER-SERVICE CARD

MIL-T TERMINALS

New Military Terminal Boards meeting MIL-T-16784B are available as single row, double row or through connected type boards, satisfying the full range of wiring possibilities.—*Kulka Electric Corp., 633 So. Fulton Ave., Mt. Vernon, N. Y.*

CIRCLE 272 ON READER-SERVICE CARD

MINI FILM RESISTORS



New micro-miniature carbon film resistors - PT30 (1/10 watt) and PT55 (⅛ watt) are only 0.156" and 0.281" long respectively. Have tolerances of ±1.0%, voltage coefficient less than .0002%/V, and temperature coefficient of −.02 to −.05%/°C.—*Pyrofilm Resistor Co., Inc., Box 1521, U. S. Highway #46, Parsippany, N. J.*

CIRCLE 273 ON READER-SERVICE CARD

MSD new literature

MICROWAVE EQUIPMENT RF/1, describes in 2-page Bulletin ECM-144, is for voice, data, teletype, facsimile and telegraph transmission.—Section P, General Electric, Communication Products Dept., P. O. Box 4197, Lynchburg, Va.

FOR THIS LITERATURE CIRCLE 274 ON READER-SERVICE CARD

MINI OSCILATORS, 4-page bulletin describes miniature microwave C-band Type 9180 and S-Band plate pulse Type 9150S Oscillators.—Trak Microwave Corp., 5006 N. Coolidge Ave., Tampa 3, Fla.

FOR THIS LITERATURE CIRCLE 275 ON READER-SERVICE CARD

ANTENNA INSTRUMENTATION, 16-page Condensed Catalog describes antenna pattern recording, receiving, transmitting and control equipment and accessories.—Scientific-Atlanta, Inc., 2162 Piedmont Rd., N. E., Atlanta, Ga.

FOR THIS LITERATURE CIRCLE 276 ON READER-SERVICE CARD

UHF TO VHF CONVERTER, Model 1405, is described in 2-page bulletin.—Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.

FOR THIS LITERATURE CIRCLE 277 ON READER-SERVICE CARD

MICROWAVE ANTENNAS, 16-page Catalog 100 describes Plane and Dual Polarized Parabolic Antennas (mesh or spun) in frequency ranges from 806 mc to 13.2 kmc.—Technical Appliance Corp., Sherburne, N. Y.

FOR THIS LITERATURE CIRCLE 278 ON READER-SERVICE CARD

WAVEGUIDE CHART, 2-page "Reference Table of Rigid Rectangular Waveguide Data and Fittings" covers all standard EIA waveguides between WR10 and WR2300, includes performance, dimensions, standard JAN flange references and cross reference between WR and RG numbers.—Microwave Development Labs., Inc., 15 Strathmore Rd., Natick Industrial Centre, Natick, Mass.

FOR THIS LITERATURE CIRCLE 279 ON READER-SERVICE CARD

FERRIMAGNETIC GARNETS, Bibliography on theory and application of Ferrimagnetic Garnets includes 19 references.—Microwave Chemicals Lab., Inc., 282 7th Ave., New York 1, N. Y.

FOR THIS LITERATURE CIRCLE 280 ON READER-SERVICE CARD

RF MAGNETIC COMPONENTS are described in 5-page Bulletin 561; includes data on encapsulated RF transformers, crystal filters and radar receivers.—Applied Components Inc., 401 E. Beach Ave., Inglewood, Calif.

FOR THIS LITERATURE CIRCLE 281 ON READER-SERVICE CARD

FLEXIBLE COAXIAL CABLE, 16-page Catalog H describes Heliax flexible airdielectric cable.—Andrew Corp., Box 807, Chicago 42, Ill.

FOR THIS LITERATURE CIRCLE 282 ON READER-SERVICE CARD

MICROWAVE COMPONENTS, 12-page Catalog HS-61 details Sidewall Short-slot Hybrids for high frequency radar and communication service.—Microwave Development Laboratories, Inc., 15 Strathmore Rd., Natick Industrial Center, Natick, Mass.

FOR THIS LITERATURE CIRCLE 283 ON READER-SERVICE CARD

ANTENNA/MICROWAVE TECHNOLOGY, 12-page brochure features products and facilities of Dorne and Margolin, Inc., 29 New York Ave., Westbury, L. I., N. Y.

FOR THIS LITERATURE CIRCLE 284 ON READER-SERVICE CARD

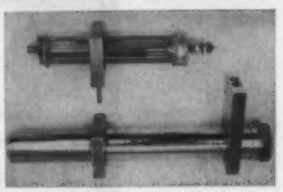
SUBCONTRACT MANUFACTURING, 16-page "Manual of Facts" describes subcontract manufacturing services.—Paraplegics Manufacturing Co., Inc., 304 N. York Rd., Bensenville, Ill.

FOR THIS LITERATURE CIRCLE 285 ON READER-SERVICE CARD

MICROWAVE ATTENUATOR, 2-page Bulletin P-2 describes Metal Film Resistance Card, a metal resistance film deposited on a laminated fibre glass plastic base which is dimensionally stable and has extremely low moisture absorption.—Filmohm Corp., 48 W. 25 St., New York 10, N. Y.

FOR THIS LITERATURE CIRCLE 286 ON READER-SERVICE CARD

MICROWAVE OSCILLATOR



New Model TS 418 microwave signal generator features a ±2 mc calibration accuracy and 0.1% resetability using a direct reading frequency tuning mechanism. Operating frequency is from 400mc to 1 kmc. When used with 2C36 or similar UHF Triodes, 10 mw power into a 50 ohm load is achieved. Power output is monitored by a bead and disc thermistor bridge.—*Frequency Standards, P.O. Box* 504, *Asbury Park, N. J.*

CIRCLE 287 ON READER-SERVICE CARD

FIELD INTENSITY RECEIVER

New Model CFI microwave Field intensity receiver system is mobile, transistorized, calibrated field intensity instrument covering the 1 kmc to 10 kmc range. Besides the basic unit, it includes four RF tuning units, impulse calibrator, five antennas and a tripod. The basic receiver features a calibrated meter to indicate average, peak, slideback peak and quasi-peak values on five scales: 1,000 μv,, db above 1 μv/mc (1mc bandwidth), db above 1μv/mc (5 mc bandwidth), 70 db relative, and 20 db linear.—*Polarad Electronics Corp.,* 43-20 34*th St., Long Island City* 1, *N. Y.*

CIRCLE 288 ON READER-SERVICE CARD

POWER SUPPLY CABINET

New Model "2C" power supply cabinet for capacities in the 12 to 45 kw range, meets shock and vibration requirements of category "D" per MIL-E-4970A. It is also weatherproof and suitable for outdoor use.—*Christie Electric Corp.,* 3410 *W.* 67*th St., Los Angeles* 43, *Calif.*

CIRCLE 289 ON READER-SERVICE CARD

LINEAR MOTION POT

New Model 150, short travel linear motion potentiometer is sensitive to movements as small as 0.00006". This new unit can be used to sense small deflections and bending movements of structures, position of miniature valves or linkages and similar applications. The spring loaded shaft drives a Flexure-supported wiper assembly multiplies input motion for fine resolution without introducing friction or backlash errors. Static error band, ±2%.—*Bourns, Inc.,* 6135 *Magnolia Avenue, Riverside, Calif.*

CIRCLE 290 ON READER-SERVICE CARD

REMOTE ANGLE INDICATOR

New three-channel, transistorized remote angle indicator for remote readout of inertial platform orientation is completely housed in a 3½" x 19" x 14" panel.

Each channel's CX-type remote angle sensor feeds into a CT resolver connected to a counter through a 360:1 anti-backlash gear train. Each position indicator displays the position of the inertial platform in degrees and minutes.—*American Electronics, Inc., Instrument Div.,* 9503 *West Jefferson Blvd., Culver City, Calif.*

CIRCLE 291 ON READER-SERVICE CARD

ACCELEROMETERS SINGLE AXIS

New single axis accelerometers which employ fluid damping and torsion-bar spring restraint are designed for low-cost inertial systems where the output is integrated to provide velocity and distance information. Complete performance characteristics on request.—*Kearfott Div., General Precision, Inc.,* 1150 *McBride Ave., Little Falls, N. J.*

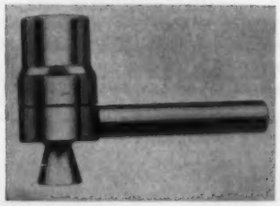
CIRCLE 292 ON READER-SERVICE CARD

IFF-TACAN ANTENNAS

New flush-mounted L-Band antennas for the supersonic B-58 have specifications of: VSWR 1.6 from 1000 to 1100 mc, probe-coupled 16 to 20 db down, power 10 watts average 2500 watts peak at 75,000 ft., weight 13 oz., temperature −65° to −260°F. —*Transco Products, Inc., 12210 Nebraska Ave., Los Angeles 25, Calif.*

CIRCLE 293 ON READER-SERVICE CARD

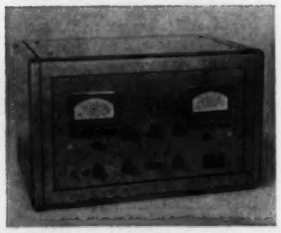
ATTITUDE CONTROL



New high response miniature attitude control valve cold gas attitude or directional control systems in missiles or space vehicles uses a low impedance type solenoid design combined with a bi-stable poppet arrangement utilizing full flow forces for very fast actuation.—*James, Pond & Clark, Inc., 2181 East Foothill Blvd., Pasadena, Calif.*

CIRCLE 294 ON READER-SERVICE CARD

TRANSISTOR TESTER



New h-Parameter Testor quick tests the four "h" parameters of any signal transistor to 2% accuracy, over wide operating ranges, in either grounded base or grounded emitter configurations.—*Tenco Electronics, Inc., 108 Cummington St., Boston 15, Mass.*

CIRCLE 295 ON READER-SERVICE CARD

TRIMMER POT. 2-page Data Sheet 184 describes new 7/16" x 1/2", Series 220 single-turn commercial composition trimmer.—CTS Corp., Elkhart, Ind.

FOR THIS LITERATURE CIRCLE 296 ON READER-SERVICE CARD

RESISTORS, POWER RHEOSTATS, RELAYS and other components for military applications are described in 32-page Catalog 50B.—Ohmite Mfg. Co., 3601 Howard St., Skokie, Ill.

FOR THIS LITERATURE CIRCLE 297 ON READER-SERVICE CARD

PRECISION RESISTORS, carbon film, metal film, wirewound, miniature, etc. are described in 4-page Bulletin SF 100.—Key Resistor Corp., Gardena, Calif.

FOR THIS LITERATURE CIRCLE 298 ON READER-SERVICE CARD

TRANSISTORIZED Digital System Modules are described in 16-page catalog 300C3. Includes system functions which are packaged on each gold plated module.—Navigation Computer Corp., Valley Forge Ind. Park, Norristown, Pa.

FOR THIS LITERATURE CIRCLE 299 ON READER-SERVICE CARD

PLANAR DIODES are described in new 12-page, three-color diode catalog S1-204/4 which describes more than 200 "1N" and "FD" series silicon Planar diodes.—Fairchild Semiconductor Corp., 4300 Redwood Highway, San Rafael, Calif.

FOR THIS LITERATURE CIRCLE 300 ON READER-SERVICE CARD

SELENIUM DUAL DIODES are described in new 2-page Bulletin SDD-1—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

FOR THIS LITERATURE CIRCLE 301 ON READER-SERVICE CARD

AMPLIFIER. 2-page brochure describes Airborne d-c amplifiers.—Microdot Inc., 220 Pasadena Ave., South Pasadena, Calif.

FOR THIS LITERATURE CIRCLE 302 ON READER-SERVICE CARD

TRANSISTORS. 2-page Application Note 15-A describes stability of Delco Radio Power Transistors.—Delco Radio Div., General Motors Corp., Kokomo, Ind.

FOR THIS LITERATURE CIRCLE 303 ON READER-SERVICE CARD

PRECISION ATTENUATOR. 2-page spec sheet describes Model AS-1 Attenuator Set.—Weinschel Engineering, 10503 Metropolitan Ave., Kensington, Md.

FOR THIS LITERATURE CIRCLE 304 ON READER-SERVICE CARD

POTTED RECTIFIERS, 10-page bulletin lists "off the shelf" Solidpak double diffused high-voltage potted rectifier assemblies.—Solitron Devices, Inc., 500 Livingston St., Norwood, N. J.

FOR THIS LITERATURE CIRCLE 305 ON READER-SERVICE CARD

TRANSISTORS. 6-page Bulletin S-16 gives design characteristics and parameters of 2N756A-2N760A Series NPN Silicon Diffused Mesa Transistors.—National Semiconductor Corp., Danbury, Conn.

FOR THIS LITERATURE CIRCLE 306 ON READER-SERVICE CARD

ARC SUPPRESSORS. 2-page Bulletin SE-1001 describes arc suppression selenium rectifiers, lists a-c and d-c type contact protectors available with voltage ranges and maximum rms coil currents for each type.—Electronic Devices, Inc., 50 Webster Ave., New Rochelle, N. Y.

FOR THIS LITERATURE CIRCLE 307 ON READER-SERVICE CARD

SELENIUM RECTIFIERS. 4-page Bulletin 400 gives electrical and mechanical specs of certified selenium cells and stacks, and cartridge-type selenium rectifiers.—Semiconductor Div., Syntron Co., Homer City, Pa.

FOR THIS LITERATURE CIRCLE 308 ON READER-SERVICE CARD

GERMANIUM TRANSISTOR. 6-page Brochure 30.67 describes Type 2N1289 high-speed computer switching transistor.—General Electric Co., Semiconductor Products Dept., Liverpool, N. Y.

FOR THIS LITERATURE CIRCLE 309 ON READER-SERVICE CARD

TRANSISTORS. 7 Data Sheets detail performance of PNP Alloy Junction Transistors.—Semiconductor Div., Sperry Rand Corp., Norwalk, Conn.

FOR THIS LITERATURE CIRCLE 310 ON READER-SERVICE CARD

MODULES. 16-page catalog describes 300 Series Transistorized Digital System Modules.—Navigation Computer Corp., Valley Forge Industrial Park, Norristown, Pa.

FOR THIS LITERATURE CIRCLE 311 ON READER-SERVICE CARD

ELECTRON TUBES. 12-page Filamentary Subminiature handbook describes characteristics and applications of tubes; 12-page Gas and Vapor Electron Tube handbook describes voltage regulator and voltage reference tubes, rectifiers, and thyratrons, decade counters and radiation counter tubes.—Raytheon Co., Industrial Components Div., 55 Chapel St., Newton 58, Mass.
FOR THIS LITERATURE CIRCLE 312 ON READER-SERVICE CARD

ELECTRON TUBES. 16-page Condensed Catalog lists complete tube line including magnetrons, microtron, klystrons.—Litton Industries, Electron Tube Div., San Carlos, Calif.
FOR THIS LITERATURE CIRCLE 314 ON READER-SERVICE CARD

INFRARED Equipment is described in 4-page Brochure "Breakthrough in Infrared Processing," including new techniques for using high intensity quartz lamp ovens and furnaces.—Fostoria Corp., Dept. 102, 1200 N. Main St., Fostoria, Ohio.
FOR THIS LITERATURE CIRCLE 315 ON READER-SERVICE CARD

SUB-MINIATURE LINEAR ACCELEROMETERS are described in 4-page brochure. Contains data on two models of sub-miniature linear accelerometers and a concise summary of basic accelerometer principles.—Fairchild Controls Corp., 225 Park Ave., Hicksville, L. I., N. Y.
FOR THIS LITERATURE CIRCLE 316 ON READER-SERVICE CARD

SERVO REPEATER. SR-113, which can be used to indicate in digital form the angular position of a remote shaft is described in data sheet DPS/AG.—Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif.
FOR THIS LITERATURE CIRCLE 317 ON READER-SERVICE CARD

SPUR GEAR RACKS. "Certified" finepitch type, are detailed in 8-page pocket folder.—PIC Design Corp., Subs. Benrus Watch Co., Inc., 477 Atlantic Ave., East Rockaway, L. I., N. Y.
FOR THIS LITERATURE CIRCLE 318 ON READER-SERVICE CARD

SERVO REPEATER. 2-page data sheet describes precise Servo Repeater.—Kearfott Div., General Precision, Inc., Little Falls, N. J.
FOR THIS LITERATURE CIRCLE 319 ON READER-SERVICE CARD

TURNTABLE. 4-page Bulletin T844 describes Model T844 portable rate turntable and complementing tilt stand.—Dunn Engineering Corp., 225 O'Brien Hwy., Cambridge, Mass.
FOR THIS LITERATURE CIRCLE 320 ON READER-SERVICE CARD

SINGLE AXIS ACCELEROMETERS are described in 2-page data sheet.—Kearfott Div., General Precision, Inc., Little Falls, N. J.
FOR THIS LITERATURE CIRCLE 321 ON READER-SERVICE CARD

PRECISION COMPONENTS. 4-page bulletin describes precision cams, mechanical differentials, synchros, Oldham couplings, and 10-w low-inertia servo motors.—Ford Instrument Co., Div. Sperry Rand Corp., 31-10 Thomson Ave., Long Island City 1, N. Y.
FOR THIS LITERATURE CIRCLE 322 ON READER-SERVICE CARD

INDICATOR. 2-page data sheet describes Type 9816-05 Drift Angle and Ground Speed Indicator.—John Oster Manufacturing Co., Avionic Div., 1 Main St., Racine, Wis.
FOR THIS LITERATURE CIRCLE 323 ON READER-SERVICE CARD

SYNCHROS. 4-page Data Sheet CS/TS-4-11-1 describes Size 11 400-cycle Thru-bore Control and Torque Synchros for servo applications.—Vernitron Corp., 125 Old Country Rd., Carle Place, L. I., N. Y.
FOR THIS LITERATURE CIRCLE 324 ON READER-SERVICE CARD

MAGNETIC PARTICLE CLUTCH. 6-page Bulletin 6005-2 explains operation of magnetic particle and friction clutches.—Vickers Inc., Electric Products Div., 1815 Locust St., St. Louis 3, Mo.
FOR THIS LITERATURE CIRCLE 325 ON READER-SERVICE CARD

SERVOMOTOR-GENERATOR. Size 5, Model 9005-1102-0, is described in 2-page Data Sheet 61179.—Helipot Div., Beckman Instruments, Inc., 2500 Fullerton Rd., Fullerton, Calif.
FOR THIS LITERATURE CIRCLE 326 ON READER-SERVICE CARD

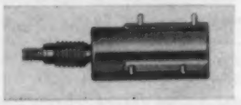
EQUIPMENT CASES doubling as lightweight shipping cases meeting MIL-Specs are described in new 12-page booklet," Standard Cases for Custom Equipment." —TA Mfg. Corp., 4707 Alger St., Los Angeles 39, Calif.
FOR THIS LITERATURE CIRCLE 327 ON READER-SERVICE CARD

MINIATURE WIRE-WOUND

New Type 261-P encapsulated precision wirewound resistor with "relaxed" windings is noninductive, with only 1pf distributed capacitance up to 800 kohm size. Rated at ¼ watt at 125°C ambient, tolerances to 0.01% available.—*Kelvin Electric Co.*, 5907 *Noble Ave., Van Nuys, Calif.*

CIRCLE 328 ON READER-SERVICE CARD

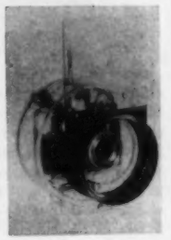
VARIABLE INDUCTORS



New encapsulated variable r.f. inductors, with single or bifilar windings meeting MIL-C-15305 are uncapsulated under vacuum to insure reliable operation even after prolonged immersion in water.—*Vanguard Electronics Co.*, 3384 *Motor Ave., Los Angeles* 34, *Calif.*

CIRCLE 329 ON READER-SERVICE CARD

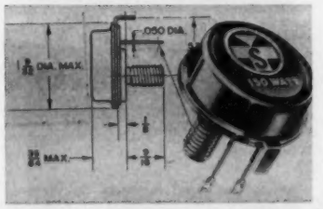
UNDERSEA CAMERA BOX



New compact plastic underwater housing is now available for the ROBOT STAR II Automatic 35mm camera, providing for pictures at depths of down to 100 ft below sea level. Up to 50 exposures without rewinding are possible.—*Karl Heitz, Inc.*, 480 *Lexington Ave., New York* 17, *N. Y.*

CIRCLE 330 ON READER-SERVICE CARD

HI-POWER TRANSISTORS



New diffused junction, NPN high power single-end stud mounting transistors have V_{ce} 100 v, R_{sat} of 0.5 ohms and min beta of 10 @ 5 amps. Types 2N1015 and 2N1016 are designed for power converters, power supply regulators, controls and servo amplifiers.—*Silicon Transistor Corp., Carle Place, N. Y.*

CIRCLE 331 ON READER-SERVICE CARD

POWER SUPPLIES. 4-page Technical Data File details solid-state miniature DC power supplies.—Technipower, Inc., 18 Marshall St., So. Norwalk, Conn.
FOR THIS LITERATURE CIRCLE 332 ON READER-SERVICE CARD

STANDBY POWER SYSTEMS requiring zero switchover time when a-c line fails are described in 4-page Bulletin 6131.—Electro-Seal Corp., 938 North Ave., Des Plaines, Ill.
FOR THIS LITERATURE CIRCLE 333 ON READER-SERVICE CARD

POWER SUPPLY. 2-page Form 95-5043 features 150-w Model W612A Mobile Radio Power Supply.—Minneapolis-Honeywell Regulator Co., Dept. QS-7-132, Minneapolis 8, Minn.
FOR THIS LITERATURE CIRCLE 334 ON READER-SERVICE CARD

POWER SUPPLIES. 6-page Short Form Catalog 1961 covers 22 major regulated power supplies.—Harrison Laboratories, Inc., 45 Industrial Rd., Berkeley Heights, N. J.
FOR THIS LITERATURE CIRCLE 335 ON READER-SERVICE CARD

RELAYS. 12-page booklet features sub- and micro-miniature relays.—Filtors, Inc., 30 Sagamore Hill Dr., Port Washington, N. Y.
FOR THIS LITERATURE CIRCLE 336 ON READER-SERVICE CARD

RELAY. 2-page Bulletin 200 describes Series 200 miniaturized 10-amp relay.—Wheelock Signals, Inc., 273 Branchport Ave., Long Branch, N. J.
FOR THIS LITERATURE CIRCLE 337 ON READER-SERVICE CARD

RELAY. 2-page data sheet describes Model 3003 electronic relay that operates with as much as ½ megohm in series with actuating contacts.—Atlee Corp., Monitor Controller Div., 99 Grove St., Rockland, Mass.
FOR THIS LITERATURE CIRCLE 338 ON READER-SERVICE CARD

RELAYS. 4-page bulletin and 2-page data sheet describe antenna, coaxial, time and thermal delay, and military type relays.—Allied Radio, 100 N. Western Ave., Chicago 80, Ill.
FOR THIS LITERATURE CIRCLE 339 ON READER-SERVICE CARD

CAPACITORS. 4-page Catalog 102 describes Type GA Glass Enclosed, High Voltage dc Capacitors.—Corson Electric Mfg. Corp., 540 39th St., Union City, N. J.
FOR THIS LITERATURE CIRCLE 340 ON READER-SERVICE CARD

CERAMIC CAPACITORS. 16-page Bulletin H-4 describes ceramic capacitors in 6 case sizes in each temperature characteristic, in dipped plastic or glass-coated form and in plastic molded cases.—Gulton Industries, Inc., 212 Durham Ave., Metuchen, N. J.
FOR THIS LITERATURE CIRCLE 341 ON READER-SERVICE CARD

FOIL CAPACITORS. 4-page Bulletin GEA-7227 describes Tantalytic foil electrolytic capacitors.—General Electric Co., Schenectady 5, N. Y.
FOR THIS LITERATURE CIRCLE 342 ON READER-SERVICE CARD

CAPACITORS. 16-page Catalog 1961-1 details miniature ceramic capacitors.—Vitramon, Inc., Box 544, Bridgeport, Conn.
FOR THIS LITERATURE CIRCLE 343 ON READER-SERVICE CARD

HEAVY DUTY DC CAPACITORS described in 4-page Catalog 103 include capacitors for use in power supplies, voltage doubling circuits, communication receivers and transmitters, X-ray equipment, energy storage, and other electronic applications.—Corson Electric Mfg. Corp., 540 39th St., Union City, N. J.
FOR THIS LITERATURE CIRCLE 345 ON READER-SERVICE CARD

MAGNETIC CORE TESTER. 4-page Bulletin 60-L describes Model 1300 Magnetic Core Tester, high speed, multiple output pulse generator that provides programmed high amplitude current or voltage pulses.—Rese Engineering, Inc., A and Courtland Sts., Phila. 20, Pa.
FOR THIS LITERATURE CIRCLE 346 ON READER-SERVICE CARD

BAKING OVENS.—4-page Bulletin 658 describes high-temp, high-vacuum rectangular baking ovens for upgrading and stabilizing semiconductor devices.—Vacuum Processing Div., F. J. Stokes Corp., 5500 Tabor Rd., Phila. 20, Pa.
FOR THIS LITERATURE CIRCLE 347 ON READER-SERVICE CARD

LAMINATED PLASTICS. 8-page brochure describes techniques, illustrates design hints for machining laminated plastics.—Synthane Corp., Oaks, Pa.
FOR THIS LITERATURE CIRCLE 348 ON READER-SERVICE CARD

CONNECTING AND SEALING. 8-page Bulletin WB-1 tells "How, When and Why to use a V-Band Coupling." —Marman Div., Aeroquip Corp., 11214 Exposition Blvd., Los Angeles 64, Calif.

FOR THIS LITERATURE CIRCLE 349 ON READER-SERVICE CARD

CERAMICS-TO-METAL. 8-page booklet describes facilities, and products of Ceramics International Corp., 39 Siding Place, Mahwah, N. J.

FOR THIS LITERATURE CIRCLE 350 ON READER-SERVICE CARD

SHOCK TESTERS. 24-page Bulletin 4-70 gives operating principles, features, applications of HYGE Shock Testers.—Consolidated Vacuum Corp., 1775 Mt. Read Blvd., Rochester 3, N. Y.

FOR THIS LITERATURE CIRCLE 351 ON READER-SERVICE CARD

AIR DATA TESTER-CALIBRATOR is described in Bulletin 532; special adapters, in Bulletins 550, 555 and 560.—Intercontinental Dynamics Corp., 170 Coolidge Ave., Englewood, N. J.

FOR THIS LITERATURE CIRCLE 352 ON READER-SERVICE CARD

INERTIA SWITCH. 2-page Fact Sheet 261 describes radial, uni-directional, and V-dot indicator acceleration sensitive devices.—Inertia Switch, Inc., 311 W. 43 St., New York 36, N. Y.

FOR THIS LITERATURE CIRCLE 353 ON READER-SERVICE CARD

LASER EFFECT. 5-page booklet describes flashtubes for Light Amplification by Stimulated Emission of Radiation.—General Electric Co., Dept. LP-15, Nela Park, Cleveland 12, Ohio.

FOR THIS LITERATURE CIRCLE 354 ON READER-SERVICE CARD

FM-MONITOR/CALIBRATOR. 2-page Bulletin 500 describes "Monocal 500" FM-monitor deviation calibrator. —Advanced Measurement Instruments, Inc., 109 Dover St., Somerville 44, Mass.

FOR THIS LITERATURE CIRCLE 355 ON READER-SERVICE CARD

MESOLOY WIRE. 4-page bulletin describes Mesoloy Wire, improved iron-chromium-aluminum alloy possessing high resistivity and low T.C. characteristics.—Molecu-Wire Corp., Eatontown-Freehold Pike, Scobeyville, N. J.

FOR THIS LITERATURE CIRCLE 356 ON READER-SERVICE CARD

RMI CONVERTER. 4-page brochure describes TSO-Certified STARFLITE I RMI Converter, includes suggested systems for six different single and dual Omni applications.—Dept. A-7-31, Aircraft Radio Corp., Boonton, N. J.

FOR THIS LITERATURE CIRCLE 357 ON READER-SERVICE CARD

DIGITAL CLOCKS and Time Counters are described in new series of six 2-page catalog sheets.—Penwood Numerchron Co., 7249 Frankstown Ave., Pittsburgh 8, Pa.

FOR THIS LITERATURE CIRCLE 358 ON READER-SERVICE CARD

COMPUTERS. 12-page Catalog lists printed material available on programming, subroutines, service routines, brochures, etc.—Philco Corp., Government & Industrial Group, Computer Div., 3900 Welsh Rd., Willow Grove, Pa.

FOR THIS LITERATURE CIRCLE 359 ON READER-SERVICE CARD

HEAT SINKS. 8-page catalog shows heat sinks and dissipators, with graphs, curves, tests and detail drawings. —Vemaline Products Co., Franklin Lakes, N. J.

FOR THIS LITERATURE CIRCLE 360 ON READER-SERVICE CARD

ROTARY SOLENOID applications are given in 2-page Leaflet 6.—Ledex Inc., 123 Webster St., Dayton, Ohio.

FOR THIS LITERATURE CIRCLE 361 ON READER-SERVICE CARD

PULSE HEIGHT ANALYZER. 8-page brochure describes Model 34-13 32-Channel Pulse Height Analyzer for Space Probe or Missile.—Radiation Instrument Development Lab., Inc., 61 E. North Ave., Northlake, Ill.

FOR THIS LITERATURE CIRCLE 362 ON READER-SERVICE CARD

COMPUTER PROGRAMMING. 28-page manual explains Philco 2000 Translator-Assembler Compiler automatic programming system which produces machine code from programmer's symbolic coding.—Marketing Dept., NP, Computer Div., Philco Corp., Willow Grove, Pa.

FOR THIS LITERATURE CIRCLE 363 ON READER-SERVICE CARD

CONTACTS. 8-page bulletin is basic guide to electrical contacts.—Tricon Mfg. Co., 8010 S. Wallace, Chicago, Ill.

FOR THIS LITERATURE CIRCLE 364 ON READER-SERVICE CARD

RELIABILITY Nomograph (7" x 10") quickly computes acceptance number for any given sampling plan. Customer can predict success rate from life test data at a 90-percent confidence level, or compute a sampling plan for his conventional risks.—Warren Schoonmaker, Raytheon Co., Semiconductor Div., 215 First Ave., Needham, Mass.

FOR THIS LITERATURE CIRCLE 365 ON READER-SERVICE CARD

SWITCHES, including rotary, push-pull, miniature, etc., are described in 4-page brochure 11-60 Section 5, EEM 4700.—Clarostat Mfg. Co., Inc., Dover, N. H.

FOR THIS LITERATURE CIRCLE 366 ON READER-SERVICE CARD

VALVES. 4-page Bulletin F-10539 describes standard sizes of air valves from 0.93" to 4.4", includes pressure drop nomograph.—Aircraft and Missile Products Div., Barber-Colman Co., Rockford, Ill.

FOR THIS LITERATURE CIRCLE 367 ON READER-SERVICE CARD

PRINTED CIRCUIT CLEANER is described in 2-page Bulletin 7.—National Ultrasonic Corp., 95 Park Ave., Nutley, N. J.

FOR THIS LITERATURE CIRCLE 368 ON READER-SERVICE CARD

FILTERS. 8-page booklet describes filters for shielded room and ground support equipment applications.—Genistron, Inc., 6320 W. Arizona Circle, Los Angeles 45, Calif.

FOR THIS LITERATURE CIRCLE 369 ON READER-SERVICE CARD

TITANIUM. 4-page Bulletin 100 presents basic design information and properties of Sintered Titanium.—Mechanical Research Div., Clevite Corp., 540 E. 105 St., Cleveland 8, Ohio.

FOR THIS LITERATURE CIRCLE 370 ON READER-SERVICE CARD

FILTERS. 2-page data sheet describes Series 49S-T and 59S-L filters for cryogenic fluids, propellants, and high-pressure gases.—Filter Engineering Dept., Dynatrol, Inc., 95 Liberty St., New York 6, N. Y.

FOR THIS LITERATURE CIRCLE 371 ON READER-SERVICE CARD

ADVERTISERS' INDEX

SMD events

AUGUST 22-25—Western Electronics Show and Convention (WESCON), Cow Palace, San Francisco, Calif. Visit Instruments Pub. Co., Inc. Booth No. P-19

SEPTEMBER 6-8, 1961—National Symposium on Space Electronics and Telemetry, University of New Mexico, Sponsored by PGSET IRE and Univ. of N. Mex., Write G. S. Bryant, P. O. Box 8366 Station Co., Albuquerque, N. Mex.

SEPTEMBER 6-8—International Symposium on Transmission & Processing of Information, M.I.T., Cambridge, Mass. Sponsored by IRE-PGIT. Write R. M. Fano, MIT, Rm 26-241, Cambridge 39, Mass.

SEPTEMBER 20-21—Industrial Electronics Symposium, Bradford Hotel, Boston, Mass., Sponsored by IRE, PGIE, AIEE and ISA. Write H. O. Painter, Jr., Publicity, General Radio Co., West Concord, Mass.

OCTOBER 2-4—7th National Communications Symposium, Municipal Auditorium, Utica, N. Y. Sponsored by IRE-PGCS, Air Force. Classified sessions require SECRET clearances forwarded to Rome Air Dev. Center, ATTN: RCIS Griffiss AFB, N. Y. before 9 Sept. For general information, write C. J. Civin, Pub. Rel., 4 Colonial Drive, New Hartford, N. Y.

OCTOBER 4-6—1961 Semi-Annual Convention, American Society of Photogrammetry, Biltmore Hotel, N. Y., Write Timothy Trott, Aeroflex Corp., 34-06 Skillman Ave., Long Island City, N. Y.

MILITARY SYSTEMS DESIGN
INSTRUMENTS PUBLISHING CO., INC.
845 Ridge Avenue, Pittsburgh 12, Pa.
Form 3547 Requested